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Raymond L. Ditmars

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The
FIGHT TO LIVE

By

RAYMOND L. DITMARS

Author of "Book of Living Reptiles," "Making of a Scientist," "Snakes of the World," etc.

With Fifty-three Illustrations
from Photographs

FREDERICK A. STOKES COMPANY
NEW YORK PHILADELPHIA

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To

DR. ARTHUR M. WRIGHT

My very good friend
who has been interested
in the theme of this book

INTRODUCTION

The earth is ages old, its eras extending through millions of years. Born through unknown celestial changes the earth, as shown by geological studies, was once hot and uninhabitable by any form of life. How or from where life appeared will ever be a mystery, but the story of the rocks shows that at first life was small and crude.

Eons went by before life attained impressive size and developed backbones. Thence sweeping through the ages was a procession of changing monsters—and many small forms among them. Thus the fight to live started in the dim past.

Among the array of attacking and protective devices developed in those times, there was rise and fall as to their value. Some grew to extremes and overburdened their owners. There was a constant try-out, slow but steady, in forms of animal life. Some long survived, and others, in relatively short periods, perished. They were misfits. Hence the foundation of the theme in the following pages started ages ago. Modern animal life is reduced in size and numbers under that of the past, but the struggle to live goes on, a mixture of attacking powers, protective devices, a battle of wits and toil.

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THE FIGHT TO LIVE

CHAPTER I

MAN'S FIGHT FOR LIFE

(*A Prologue*)

IN THE great lecture hall, where scenes were being flashed by stereopticons upon the screen, the professor of ethnology was telling a fascinating story—the rise of man from remote times. I had gone there to check some research work on that subject. The lecturer was a scientist. His deductions would close my lists of notes.

A sound ran through the audience—a murmur of surprise and doubt. It came from the lecturer's expressed conviction that the human form had appeared upon this earth about a million years ago. Yet, he explained, this was comparatively recent when figuring geologic time. He cited the earth's tremendous calendar as portrayed by the rocks and their strata, the latter lying one upon the other, like pages of a book, each with its different kinds of fossils; how in the slow upthrust of mountains strata of former ocean floors might now be found at elevations of thousands of feet; how the mountains had risen through eons, then rivers, through great periods, had worn their way downward, thus disclosing these stone pages of time.

To convince his listeners, the speaker told how different types of scientists had figured on the earth's calendar—geologists, mineralogists, chemists and geophysicists; how in producing a composite picture there was a fair average of estimate among these separated workers. Then came his mention of staggering figures, of the estimated duration of different ages or periods when strata of forming rock and eroded soil encased and preserved their different forms of life from primitive creatures through massive dinosaurs, through uncouth and gigantic mammals, to the present.

Again there were murmurs, as the earth's calendar was unrolled: The Cambrian, seventy million years; the Ordovician, ninety million; the Silurian, forty million; the Devonian, fifty million; the Carboniferous, eight-five million; the Permian, twenty-five million; the Triassic, thirty-five million; the Jurassic, thirty-five million; the Cretaceous, sixty-five million; the Eocene, twenty million; the Oligocene, sixteen million; the Miocene, twelve million; the Pliocene, six million; and the Pleistocene, one million years. A fair representation of the Pleistocene continued to exist. These periods of years, the lecturer explained, were approximate, in figuring out an average from the estimates of scientists who had studied the age of the earth when life existed and left definable traces.

He summed up the total of these periods of life. In citing those ages to indicate the long calendar, he had quoted a total of 550,000,000 years. This, he said, explained his former statement, that in tracing prehistoric man it was indicated that human-like forms appeared upon the earth in comparatively "recent" geologic time, even though that might be as long as a million years ago.

That man sprang from a branch also giving rise to the apes is a general scientific deduction. Strange fossil skulls, with low foreheads and protruding brow of bone have been found in different parts of the world. The modes of life of the owners of these remains can never be surmised except that such beings would seem to have been too scant in brains to have had any idea of the use of tools or weapons. But manlike forms worked to the north, still invaded by great areas of glacial drift. Behind this pioneering there may have been the influence to leave behind disease of the hot latitudes and the great variety of savage wild beasts. As man's prehistoric ancestors spread into regions where there was cold, there came the need for body covering. In these northern races of early man there arose a rapid development of mentality—a distinct separation between man and mere animals. The traces to show all this are many. Early man fashioned tools of stone and flint, and weapons of like material. He became a hunter both for sustenance and for hides and furs to clothe himself. The dominance of humanity over the wild life of the earth had begun. Long before the dawn of civilization, man had learned to build shelters and was carving upon the rocks fair figures of trophies of the chase.

Even with early civilization, man had much to learn about the fight to live, but that aim was uppermost. Humanity had inherited ideas of weapons from savage ancestors. The bow and arrow and cold steel were improved in detail and effectiveness. Organized warfare, wave after wave of it, swept Europe and to the east. The fight to live, for centuries, thence resolved itself into a series of gory struggles, and the invention of gunpowder added to the carnage. This trend of battling humanity influenced the writing of the Bible, which contains the terse sentence: "There will always be wars or rumors of wars."

The intelligent fight against disease came slowly. Fair surgery was far ahead of it. Sanitation lagged far in the background. The first medicines were associated with witches' brews and incantations. Early surgery was ghastly in its brutality; sufferers endured it, but only the strong survived. As late as the Civil War in America, chloroform was not generally available for operations, and surgeons spoke of "laudable pus" in wounds that would have horrified the modern practitioner. The existence and action of specific disease germs or bacteria was unknown. The fact that certain insects transmitted deadly diseases was undreamed of.

Since that time humanity has climbed heights of knowledge in the struggle to exist and prolong the span of life. Compare the present with a not too remote past. In 543 A.D. ten thousand persons died from bubonic plague each day in Constantinople. In the fourteenth century the plague became epidemic in Europe and is estimated to have killed over twenty-five million persons. It has killed at least ten million of the population of India. The death-toll from Asiatic cholera has been almost as bad, and deaths from malarial fevers form a sinister total. The diseases of children ran into grim figures in the annals of the past. Such calamities that have struck the human races appear to be characteristic in smiting man and the lower, invertebrate forms of life. The larger wild animals are relatively free from death by epidemics.

What has been done to end those tragedies of the past? Science swung into a fast stride, the workers becoming specialists in the fight to conserve human life. The microscope revealed that ultra-minute forms—or germs—were the common cause of disease; that different diseases were caused by distinct species of bacteria. Wounds were protected from invasion of germs or wet dressing applied to retard their multiplication if they invaded the tissue; surgery became aseptic. It was learned that germs threw off toxins that overwhelmed the human system. This was the cause of death from disease. With a number of maladies it was found that a mild toxicity, produced from the poisons of germs that had been killed, could be administered to healthy humans and they would afterwards be resistant to disease or poisoning caused by such germs. Such was prophylaxis. It has saved hundreds of thousands of human lives. The dread of smallpox was thus practically wiped out as a scourge of civilization; and later came the blessing to children in the prophylactic treatment for diphtheria. Similar measures are preventive of typhoid; and anti-tetanus injections have materially changed the sinister story of wounds in warfare. The fight goes on. The cruel blight among children, infantile paralysis or poliomyelitis, is on the verge of prophylactic control, as are other diseases.

Gland therapy, as indicated by the blessing of insulin and rapidly developing knowledge of the functioning of glands, is opening the door to a new understanding of the development of better and stronger human bodies. The X-ray and radium are a part of humanity's fight to live.

I can remember helping to weave a thread or two into this safe-guarding fabric, in the work to produce serums to save life from the bites of poisonous snakes. As with the germs, the reptilian hazards to human life were corralled in the laboratory and put to work to assist in producing remedies against the very dangers they created. The snakes were "milked" of their poisons by cautiously holding them by the neck and inducing them to plunge their fangs through parchment tied over a glass jar. The poisons thus obtained were modified, then injected into horses; enough at a time to produce an appreciable though not dangerous effect. Month after month these injections went on, the injected horses battling against the venom and finally building up a resistance or immunity to it. After eight to ten months of the work, the horses could withstand what formerly would have been many times a deadly dose.

Blood was drawn from these horses, a considerable quantity, but not enough to injure the animals. The serous or yellow portion was separated and concentrated by filtration processes. This serum was placed in glass tubes sealed with a flame. It was ready for hypodermic injection into human victims of snake-bite. The serum of the immunized horse produced a strong resistance in the human to the action of the poison. In other words, it tended to neutralize the poison, a measure similar to that used in fighting the toxins or poisons of disease germs. In this way we worked with the venom of rattlesnakes, the fer-de-lance, the cobra and other lethal kinds, each radically different group of snakes producing a serum against its own venom. The effects have been marked in decreasing the death-rate from poisonous bites throughout the world. In South America alone, the figures point to a decrease from several thousand a year to less than a hundred annually.

There is a group of men which should receive high recognition in the saving of human life. These are the entomologists—the insect specialists. It is through their studies that some of the world's most appalling maladies have been fathomed. Malaria and yellow fever were traced to transmission by distinct species of mosquito, sleeping-sickness by the tsetse fly, and bubonic plague by fleas from infected rats—and there are other equally formidable insect offenders. The work of entomologists has brought world-wide relief in combating pestilential insects. Of late years these men have achieved important results from another investigation: the study of parasitology, of minute insects that prey upon and keep in check the insects injurious to man.

These are some of the bulwarks with which man is now surrounded. With his drive to seek domination of the earth, to be fortified against natural forces and protected against attacks of members of his own kind, this prologue sums up in a curious analogy some of the material of the chapters of this book. Those chapters form the detailed story I have been guided to write. Man's rise has been so rapid that, in relation to the development of other forms of life, it seems highly artificial. He has abruptly subjugated natural forces which have taken great periods of time to come into being—in the natural scheme of life. In his short, dominating reign on earth, he has copied, consciously or unconsciously, a procession of useful and protective devices that have existed among wild creatures through the ages. From rough, cave-man tactics, he graduated from stone hatchets to studded war-clubs, on a parallel with the spiked, pounding tails of the ancient glyptodonts. He took to protective armor, which in nature had come into use millions of years before the dinosaurs. In making the hypodermic needle he duplicated the serpent's fangs. And, to cite several others out of many imitations, there is the modern adaptation of camouflage, a natural art going back millions of years; the use of electricity, which was utilized among fishes long before the advent of cave-men; smoke screens and poison gas—age-old defenses among primitive forms of the sea; the art of flight, which first appeared among the pterodactyls or aerial reptiles a hundred million years ago; the prowling under water by means of diving-bells and submarines; and devices for ultra-sensitivity to sound waves, which existed among primitive insects.

The composite picture points to a sort of plagiarism of long-established, natural developments. But thus humanity seethes with measures of protection and advancement. The picture is brilliant as regards the advancement of the races of men, but again there are scientists who declare that such strides have been too rapid, who speak in dire terms of excess population and point to the rise and fall of past civilizations as shown by ruins of former strength and magnificence which antiquarians exhume for museum exhibits. Certain it is that the present civilization far surpasses in protective measures anything of the past, and modern races are seeking further immunity from hazards which may ensue. This weakens ominous forebodings, except from the viewpoint of excess multiplication of humanity.

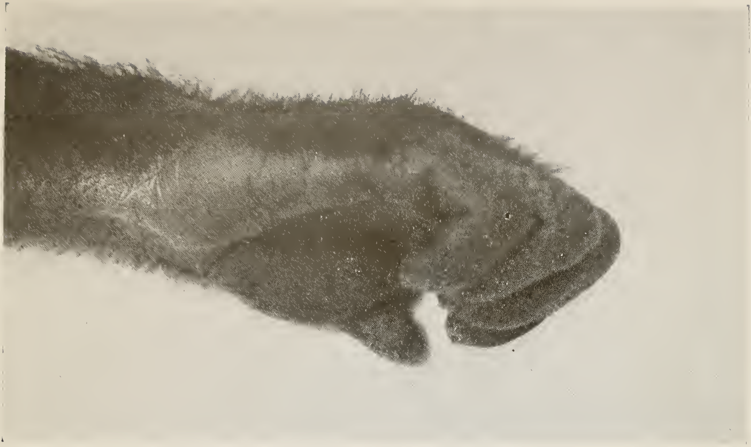
CHAPTER II

THE ANTHROPOID APES AND THE MONKEYS

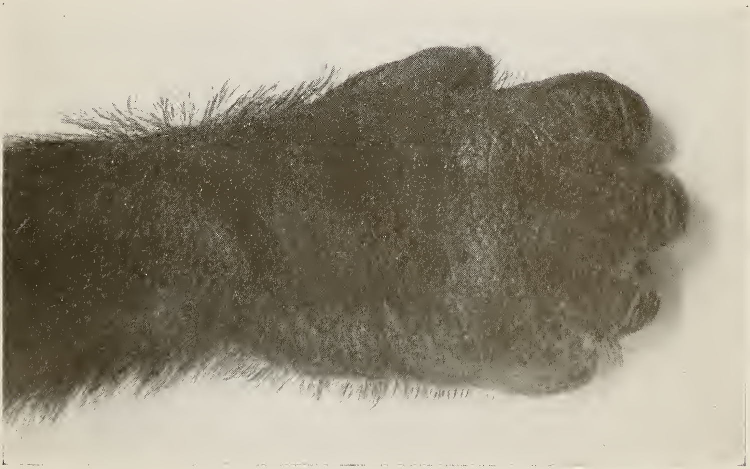
ONE step down from man in the scale of animal classification—and how the picture changes! Figuring from the "highest" to the lowly wild animals, there is a strange quartet placed at the top by the scientists who arrange the scale of zoology. Occupying this position over the legion of mammals are the four types known as the gorilla, chimpanzee, orang-utan and gibbon, three of which have developed species and races. These are the so-called "smartest" animals. They are designated as the "man-like apes." This comes from their similarity to the human form and the relatively large size of their brains. From this it would seem that their struggle to exist would be far more ingenious than with the greater number of animals, particularly when they are provided with hands and that alleged digit of character called the thumb.

It has been asserted that man ascended with the development of his thumb, producing a hand of great dexterity for the fashioning of weapons and implements. That assertion seems weakened when one looks at the hand of an anthropoid ape, for here are thumbs and elongate hands of great strength. The allegation seems still weaker in studying the monkeys. Among those forms, rated as more lowly than the apes, are better thumbs and as deftly opposable to the fingers as the vaunted digit of the human. Thus with hands, workable thumbs, and reputed mental superiority, how do apes and monkeys fare in the battle of life? The story is a strange one. It is full of inconsistencies.

The average wild gorilla, chimpanzee and orang-utan are tremendously strong for their weight. Physically, they are so much superior to a human in utilizing their muscles that an anthropoid ape has at least the power of two men of its weight. Right here fair comparison swings wide apart. There is a gap in which relationship seems to be eliminated. The mentality of these animals when wild runs at a lower level than a half-witted human's. They have keen, forest-roving spirit, but so do average animals. The apes build no shelters,



Hand of Gorilla, showing human-like structure of thumb, which is opposable to the fingers.



Top of Gorilla's Hand, indicating action of the fingers for grasping and forming fist.

African Mandrill. Among apes, monkeys and baboons, it is only with the latter that there appears to be an understanding of weapons. Baboons will hurl stones.

African Potto. Such lemuroids are rated among the most lowly of the primates, but have grasping digits similar to apes, monkeys and baboons.

store no food, are wasteful and destructive in their feeding. The only approach to adept use of their powerful hands is in making flat nests of branches in the trees, where they may sleep; but these crude gatherings are as nothing when compared with the skillfully prepared nests, shelters and burrowed homes of the smaller animals well down the scale of classification—where hands are absent.

A strange thing among the apes is their response to the conditions of captivity. They are keenly observant and seek to imitate, even utilize implements which they see in human hands. Orangs, particularly, soon get the idea of the use of a lever and if they can break away a trapeze bar may try to pry the metal of their cages apart. I have watched orangs that had learned to drive nails and others which could remove tight nuts with a wrench. There was one who could select a key from several on a ring, then open a lock. Such actions were not drummed into these creatures by training. They came more from watching things that went on around them. Thus is their response in elevating them above the mental plane of mere animals—when they are captive. Much more could be outlined if the observations of animal psychologists with various devices and arrangements for studying captive apes were summarized. I have noticed that the younger apes are much keener in their mental activities; that matured individuals become morose and shed their human-like actions. Keenness of mentality and initiative appear to be dulled by savagery. Thus, demonstrations of anthropoid intelligence are in reverse to those of human intelligence. With the human the child has more of the animal nature than the adult, who is swayed by a brain seething with thought. The young anthropoid ape appears far more deductive than the adult. Animal psychologists may not agree with me, but I am basing this upon more than thirty years of experience with gorillas, chimpanzees, orang-utans and gibbons, and I have seen many grow to maturity and attain ages well in excess of twenty years.

One thing the brightest of captive apes fail to grasp, fortunately, is the idea of using anything as a weapon. I say fortunately, as full-grown apes, retaining such an idea, could be very dangerous customers with a club or a pointed stick, or they could hurl a stone of such weight it would kill a man. I have had experience with a number of large, murderous apes, but if they had had a chance to attack, even though surrounded with sticks and clubs, it would have been with teeth and tearing hands. There would have been no idea of a weapon, not even a thought of clenched fist, which could have given a knock-out blow.

Thus I am not inclined to give the anthropoid apes a high mark as regards the theme of the fight to live. In the habitat of all of them there has been contact with native human races, some of these crude types of man, but all building ingenious shelters, storing food, adept in the use of hands in weaving, fashioning weapons and implements. So close is the contact between such humans and apes that the latter raid farms and cause wanton destruction in their wasteful methods of eating. But in such contacts, strangely enough, that perceptive and imitative spirit seen with young captive specimens is dormant. Thus in a wild state the apes are on no better plane than the average wild animal. Human-like in form they may be, but there is an immeasurable gap between them and humanity, although the apes have a brain which in form and proportionate weight is closest in the animal kingdom to that of man.

In discussing the brain development of anthropoid apes, Dr. Daniel Giraud Elliot, in his *Monograph of the Primates,* states: "The brain of the Chimpanzee corresponds in all its physical details very closely to that of Man. The fissures and convolutions are identical; even Broca's convolution, which is the seat of articulate speech, is also present. Why, then, if these Apes are provided with a brain so like that possessed by Man, do they not talk and accomplish many of those things which Man, the greatest of all Primates, is able to achieve? The only explanation that seems reasonable is, that the indescribable, mysterious and powerful Influence which is called the Ego or Will, is lacking in the Ape, and the possession of which raises Man alone above all created beings and makes him the responsible creature that he is."

Dropping to the plane of the monkeys, which zoologically are considered inferior to the apes, the story runs nearly parallel, but not quite. In sly alertness, activity and a few other developments, the monkeys are better fitted to endure the invasion of enemies into their domains—particularly man—than the anthropoid apes. Strangely enough, although a good step down the scale, many monkeys have better thumbs, proportionately longer and making better contact with the fingers, than have the apes. Such hands are deftly used in holding food, in extracting morsels from difficult places, in play and grasping during combat. Yet again, among these smaller primates—of which, of species and subspecies or varieties there are nearly five hundred kinds—there is again the lack of tendency to conserve or store food, or construct any kind of shelter.

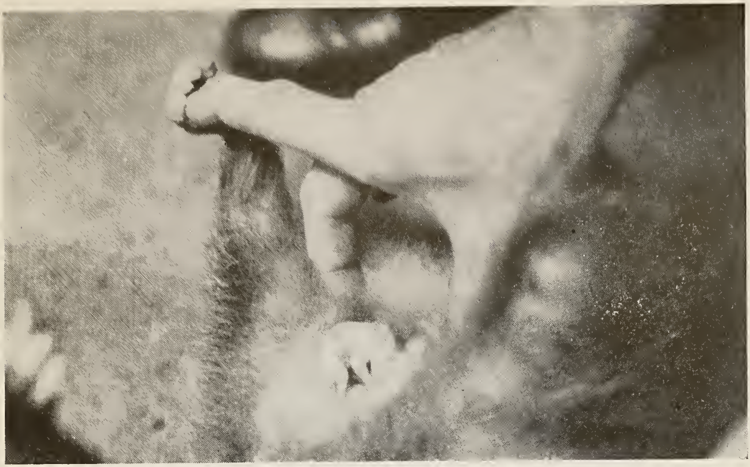
While thought of weapons has not cropped out among the greater number of these agile-handed creatures, even lower down the scale, among their most brutish members, the baboons have acquired the habit of throwing stones, with force and accuracy.

Among natural weapons developed among the monkeys are the big canine teeth of the adult males of many species. Truly, with some of the larger Old World species, particularly the African baboons, these teeth are sinister in their extreme length and their flattening of front and rear portions to knife-like sharpness. The mature and savage males well realize the power of inflicting wounds with such teeth, and when in sullen mood stare at the observer, yawning again and again to display their dagger-like weapons. With animals so provided it would seem there would be no thought of hand-used weapons. But it is among those kinds with the most excessively long and sharp canines—the baboons—that the habit of stone-throwing has cropped out. Baboons are much more terrestrial than monkeys, usually living in troops, often boldly frequenting quite open country. Of all the primates, I have the utmost respect for them in the bold showing they make.

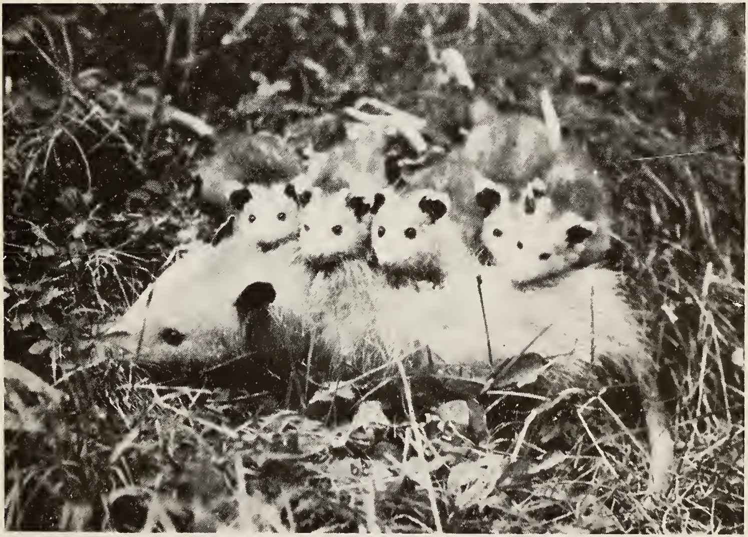
It is only among monkeys of tropical America that prehensile tails have been developed; and only among monkeys of the Old World that elastic cheek pouches for temporary storage of food have evolved. The prehensile tail is a fine safeguard during a life spent largely in the trees and often at lofty heights away from enemies. That type of tail, with its bare under-portion, like the grasping portion of a finger, is as useful as a fifth limb. The elastic cheek pouches are of even greater value. They greatly shorten feeding periods in areas that may be dangerous. Instead of waiting to chew and swallow the food, monkeys so provided jam the distensible cheeks with food, then retreat to safe places. The food is thence pushed into the mouth, masticated and swallowed at leisure. I have seen monkeys which in sitting posture were barely fourteen inches high stow an entire banana in their elastic cheek pouches.

There is one phase of habits among monkeys for which they should be given due credit, and that is their vocabulary. In the production of sounds which mean definite things, they rank higher than members of the other orders of mammals. Again, it is strange to say, anthropoid apes, standing at the head of the class zoologically, must be given second place in production of deducible sounds. Once more I revert to years of observation of apes, monkeys and baboons. The monkeys are by far the most vociferous in sounds to be noted and classified, and the Old World kinds excel in such vocabularies. To say that monkeys talk would be stretching the point, but they utter sounds as definitely unvariable as human words in expressing pleasure, condolence and assurance in relieving fear, calls to congregate, "conference" sounds when groups are assembled, sounds of caution and sounds of imperative warning. Besides these sounds, many kinds have developed facial grimaces, movements of the eyelids, wrinkling of forehead, even wiggling of ears—all having definite meaning. But again, without being interminable in criticizing the primates for neglect of their hands, I have never seen a monkey beckon, point, or make deprecating gestures. The closest to gesture with the arms has been an extended reach of supplication or begging; but bears, raccoons and canines do the same thing.

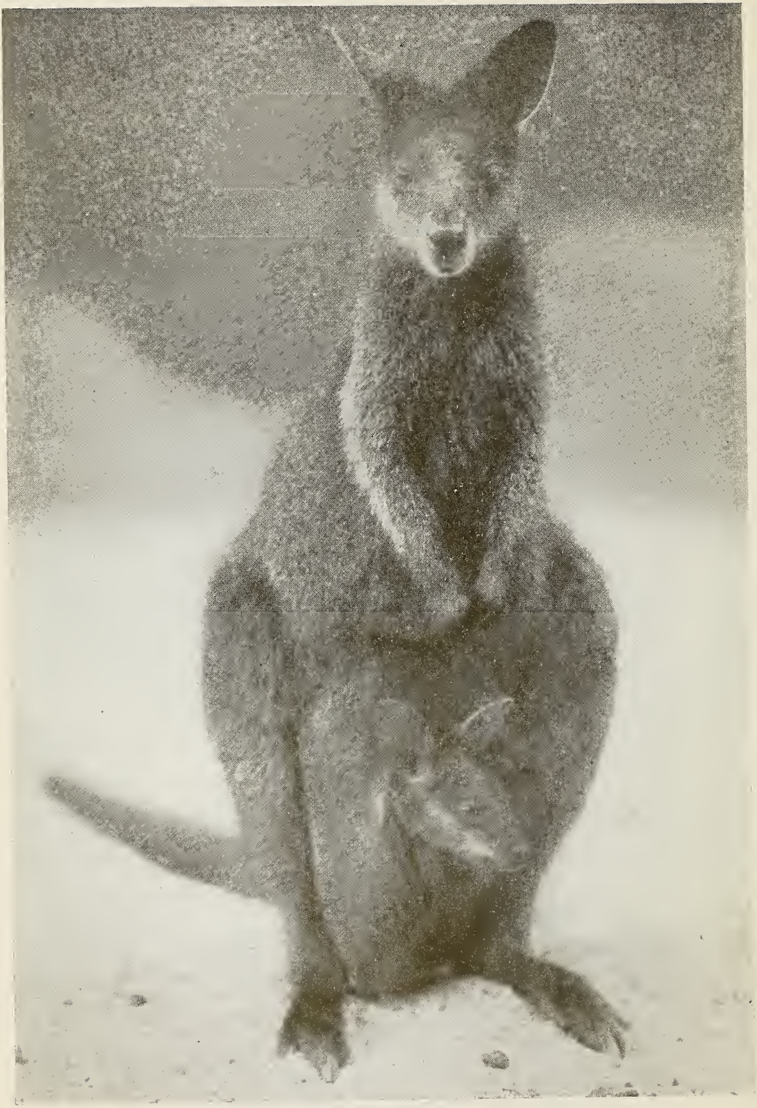
One thing about the use of hands should be remembered as a credit to the monkeys. They clasp and carry their young wherever they go. Hence the entire family is mobile. The infants are never left alone, as is the case with many mammals. But, then again, numerous mammals of much more lowly orders also carry their young. Bats transport their young; the sloths and anteaters carry



Young of the Opossum. Marsupials are extremely fragile at birth, hence are sheltered in the mother's pouch.



Opossum and Young. The large litter is crowded from the pouch and transferred to the mother's back.



Brush-tailed Wallaby and Young. With all the marsupials the young are carried in a pouch during their early development. The young wallaby is about six months old.

their infants on their back; and the marsupials, from the largest kangaroos down to the opossums and marsupial mice, stow their young in snug abdominal pouches while the progeny develops.

Against the insidious, hidden things that form waves of the attacking forces in the fight to live, the primates have less resistance than animals lower in the zoological scale. In a group of monkeys which I examined in Panama—specimens representing several species freshly captured in the nearby jungles—it was surprising to see how disease organisms had seized them as hosts and with effects far more apparent than with other wild creatures of the tropics. Their blood contained malarial organisms, their livers and spleens were bad, their intestines carried weakening parasites, and the skin showed fungoid infections. Although obtained from separated troops, collectively there was no better diagnosis to apply to them than a rather sickly lot. Such is not the average condition of the wild felines or the smaller carnivores, the hoofed animals or even the rodents.

Thus an outline chapter of these creatures that have been listed as nearest to man does not offer high spots as regards the specific theme I am seeking to portray. The greater interest—the traits of keen ingenuity, bravery, industry and extremes of development with Nature's award of weapons to face a world of hazards—comes much lower in the scale of what we call classification.

CHAPTER III

TEETH, CLAWS, HORNS, ANTLERS, SPINES AND ARMOR

WEAPONS in great variety appeared on this earth long before prehistoric man ever dreamed of them. Weapons of offense and defense and protective armor existed long before the appearance of any warm-blooded life.

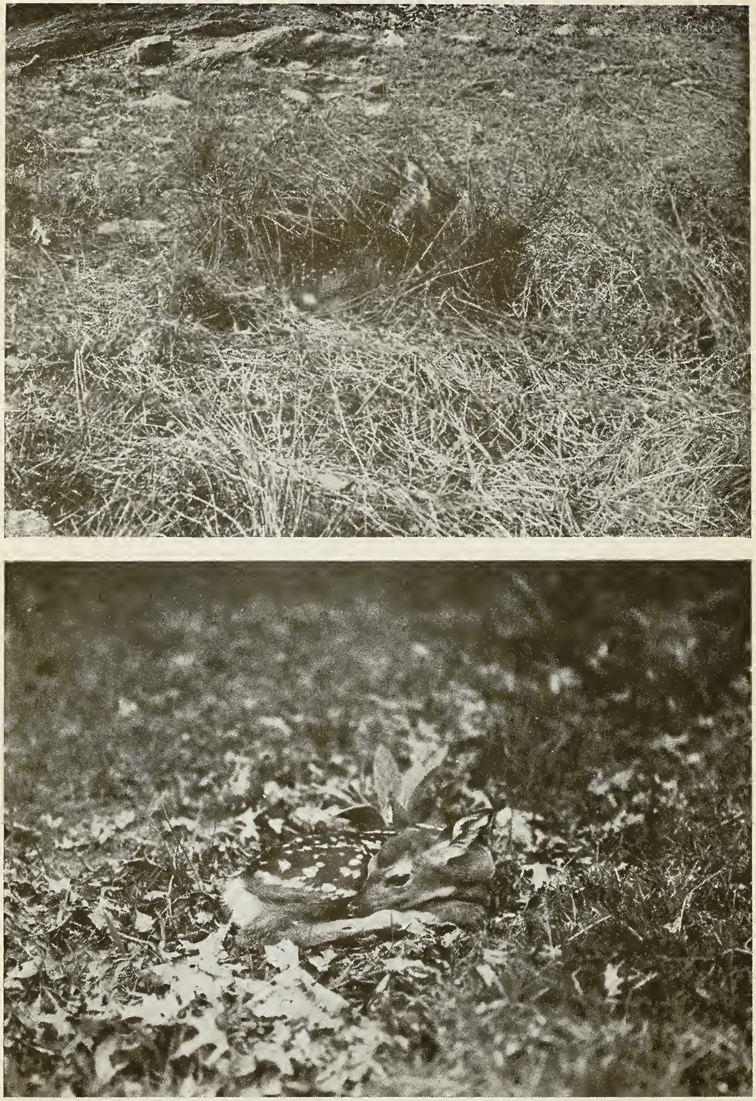
At least one hundred million years ago, there was a variety of weapons and defenses among reptilian forms that might be compared to visions of a nightmare. No such awful provisions exist among animal life today—in fact, little more than hints of that ancient array of devices are to be seen. Enormous scythe-like teeth were evolved, and in opposition were head rams, huge forward-pointing spikes, or vertical weapons for a ripping upthrust. The array of tearing claws ran riot. Protective armor ranged from tough, leathery covering to overlapping horny shingles and close-set shields of cumbersome bony plate. Some of the inoffensive, plant-eating dinosaurs or early reptiles were weighed down with armor. Stegosaurus was an example. This dinosaur was a land reptile. It was twenty-five feet long and weighed as much as a modern elephant, which only fairly rivaled the size of some of the flesh-eating dinosaurs. Allosaurus, fifty feet long, weighed several tons, a pursuing land terror bristling with enormous teeth. Stegosaurus was slow-moving, with an extremely small head, but its back carried a double row of enormous, tough plates, and standing upright near the end of the muscular tail were four spikes as long and heavy as the horns of a steer. Later, when warm-blooded animals developed in variety of form, weapons similar to those of the reptiles appeared—provided to monsters and smaller forms alike.

Every type of offense and defense that exists among warm-blooded animal life of today was evolved long before the advent of man. The study of fossils discloses the extinction of a great variety that were try-outs and turned out to be misfits. Life struggled to exist, but the odds against overdevelopment were too great.

What is the classification of offensive and de-

African Gnu. Horns and antlers are effective weapons and exist in variety of form and size.

American Elk. Antlers are used for defense and offense. Such head weapons differ from those of horned animals in being annually shed and renewed.



Camouflage of a Fawn. The spots break the outlines and are retained while the animal is frail, hiding it while the parent forages.

fensive measures of the mammal life of today? The same battle goes on. There are the hazards from predators; with many small kinds the needs of gathering and storing food; there may be special provisions of protection or changes of habits with the seasons. With the greater number, the enemy hazard is ever present, hence the wiles and counter-measures of the hunted.

Lions, tigers, leopards and the like recall the sinister, prehistoric picture when a great number of flesh-eating monsters roamed the earth. The combination of size and numbers of the modern flesh-eaters has been greatly reduced, but there is enough of danger, everywhere, to produce an animal world of alertness and fear. This has brought keen senses, while Nature has helped in creating physical defenses. Against the attacks of the big carnivores, horns and antlers are fairly effective. They are far more effective, however, against such enemies as wolves and their allies, when grasping and tearing claws are eliminated. Of greater value to the hunted hoofed animals than weapons, are super-keenness of scent, speed, protective coloration and markings. There are antelopes that can run at speeds in excess of sixty miles an hour, while leaping powers have been marvelously perfected among antelope and deer. Obstructions are cleared in soaring bounds, while the enemy must follow with all feet on the ground.

Forest-blending hues are the rule among hoofed animals liable to attack. The white stomach has been shown by photographic research to blend into its surroundings the underside of an animal's body that might otherwise become more prominently outlined if darkened by shadow. What appear to be vivid markings of such kinds as ringed antelopes, zebras and giraffes are a part of a natural camouflage in breaking the outlines of animals among foliage, where sun-slashes and shadows alternate. In the open, such strongly-marked forms are tuned to high tension of sight, scent and hearing. The spotted deer fawn, for a time incapable of following the mother, is an example of how bright markings break the outline of a body and blend with certain backgrounds. The mother keeps to the thickets with her fawn and the youngster lies quietly and alone while the parent wanders off to browse. I can attest to the deceptiveness of these "hidden" fawns, as I have known where they were, looked for them and stood almost over a fawn before locating it.

Among the smaller predators and the kinds they attack, there is far greater variety in species, hence wider ingenuity in methods of attack and defense. By the smaller predators, I mean the smaller cats, foxes and wild dogs, raccoons, badgers, mink, weasels, civets, numerous allies of the mongoose and the like. Relatively, to the small creatures they seek as prey, they are more dangerous than lions and tigers. They feed more frequently; some are extremely active, they exhibit all sorts of sly devices, have exceptional strength of jaws, and others have teeth of great relative length and keenness. Their world and the world of their prey is a realm in the matching of wits. The killings of the predators keep the scale of life balanced. To abnormally reduce their numbers, as man is much inclined to do, means the excess multiplication of the other types, many of which can be highly destructive to forests and fields—and the products of man himself.

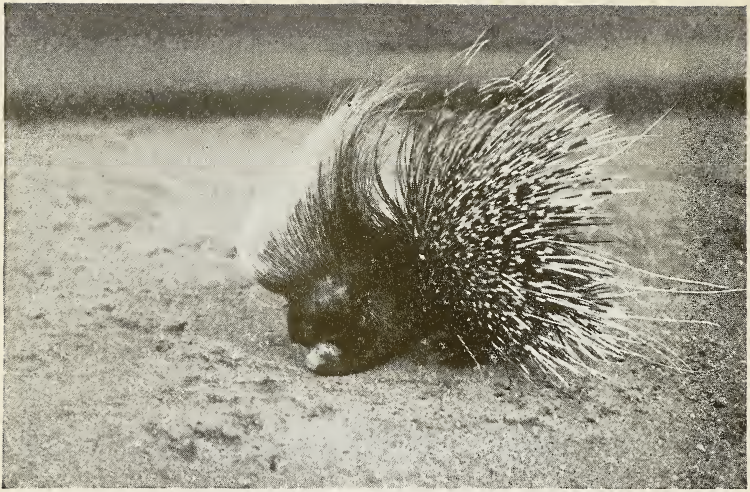
As with the larger kinds among the hunted, there are the highly tuned senses, while protective coloration figures strongly. There are kinds that are brown in summer to match the debris of the forest floor and white in winter to make almost invisible progress under the curling ledges of snowdrifts. These brown and white phases of pelage have also developed among some of the flesh-eating kinds.

Shelter as impenetrable as possible is a defense sought by many that take up their abodes among masses of rock or dig deep burrows. Many small animals have adapted themselves to a life in the trees—safer than on the ground—but birds of prey are to be watched for and some of the carnivores are deftly arboreal.

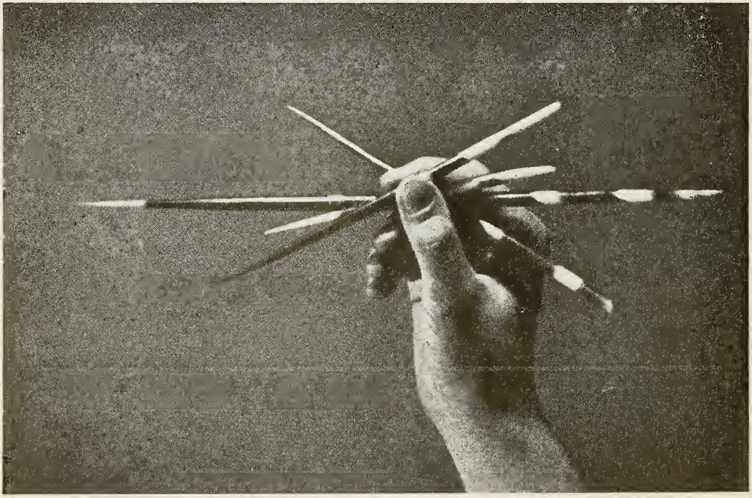
Of the body defenses of the smaller mammals, such structures mostly remnant hints of a teeming world that battled for life in prehistoric times, the most notable are spines and armament. A bristling spiny covering, the spines erectile, is a defense with which Nature has been generous. It exists among unrelated animals of various parts of the world. The largest thus provided are the porcupines. With the heavier-bodied species of Africa, India

Canadian Porcupine. Numerous sharp spines are concealed in the pelage.

Brazilian Porcupine. Spiny armament has been bestowed among a number of unrelated animals. This species has a prehensile tail, like a monkey.



African Porcupine. One of the extremes of spine-equipped animals.



Spines of the African Porcupine.

and Malaysia, the quills or spines are long and dagger-like and may be so raised at will that they flare about the owner in formidable array. With the New World kinds, they are relatively short, but equally protective, as they are more numerous.

A porcupine awaits the close approach of the intruder, then gives a vigorous nudge. The action may be accompanied by a lash of the spine-studded tail. A number of the minutely barbed quills are always loose, ready for agonizing contact and to be left with the offender. The spines are difficult to remove.

Among such spiny animals as the hedgehogs, of which there are a number of kinds in Europe and Africa, their actions upon attack are different from those of the unrelated porcupines. The latter are rodents, while the hedgehogs are insectivorous mammals. An average-sized hedgehog is about the size of a big rat. When frightened it rolls into a ball, looking like a magnified chestnut burr. Its snout and legs are tucked and hidden within the muscular coil. If a hedgehog is not caught unawares, it is almost impervious to attack.

Far down the scale, at the tail-end of mammal classification, is a small group of animals which have the strange habit of laying eggs, hatching them like a bird, then rearing the young with milk. There are only four animals in this group: the Australian duckbill, the Australian echidna and two New Guinea echidnas.

The echidnas have short, but very stout spines, relatively heavier than those of porcupines. The armament is sharp and formidable, but does not protect the lower sides and underparts, hence echidnas roll into a ball like hedgehogs—compared with which they are much larger; but they have another defensive habit, and an ingenious one. They are able to shuffle their way quickly into the soil by means of strong, clawed feet. With body about half imbedded, only the bristling back of the animal is exposed. The feet are thrust outward into the soil and the echidna is thus anchored and difficult to dislodge.

There is a common idea, but without truth, that the spiny animals can, at will, shoot their quills at an enemy. The belief has probably come into being by observers seeing an occasional loose quill flying from an angry porcupine as the animal twists and shakes its body. I have never seen more than one or two quills shaken off at one time and even at that it is not a common thing to see. From the direction in which the spines were thrown, there seemed no hint of real intention to "shoot" them at an enemy. Nevertheless, animals become wary from the influence of scattered experiences among ancestral stock and the possibility of loose quills flying off an angry porcupine may have increased respect for the owners of bristling armament.

The giant anteater of the American tropics has an effective defense, although at first sight it might appear as lumbering and helpless—it attains a weight of close to a hundred pounds. It has an immense tail of long and bushy hair like a huge fan. The other end of the animal is like an elongated spout, terminating in a mouth utterly out of proportion to the creature's size. The mouth is barely large enough to admit the end of a man's little finger—and is toothless. It can, however, eject a sticky tongue a foot long which whips streams of ants from their burrows.

All thoughts of biting in retaliation for attack are, of course, absent from the mind of this or any of the smaller anteaters. When attacked, it rears and erects a pair of claws on each forefoot—these claws ordinarily doubled inward when the animal is walking. The claws are longer than those of a tiger and the effect of a sweep with one of the powerful forelimbs may be surmised.

I felt the effect of a similarly aimed stroke from a little silky anteater in Panama, an animal about half the size of an opossum. The furry creature was in a low tree, rearing on hind feet, the position supported by its prehensile tail. It looked alert as it stared at me with dark eyes like bulging shoe-buttons. At the same time, its attitude seemed meek and quiet; its mouth a tiny orifice just large enough for the darting of the slender, ant-catching tongue. I attempted to give it a gentle poke with my finger, but with the approach of my hand there was a stroke of the anteater's forefoot and my thumb was slashed to the bone.

Armor-plating, while an old story as regards geologic time, is passing out among mammals. Present-day mammals so provided are pygmies as compared with those of the past. The New World armored mammals are armadillos, found from southern Texas throughout South America. There is but a small number of kinds, ranging in size from the giant armadillo, five feet long including its tail, to the little pichiciago of Argentina, which is little more than five inches in length. These animals have a number of bony plates in the skin, forming a more or less complete shield, the whole overlaid by a leathery surface. The shields are in bands, with flexible skin between, the structure similar to human-made armor, movable, but protective covering. Thus an armadillo can roll into a tight ball, its head and limbs within the covering, held tightly closed by strong muscles.

Despite this shielding, the armadillos, except the single giant species, lead anything but a carefree life. Their flesh is good eating and they live in a region inhabited by two powerful cat animals—the jaguar and the puma—with claws strong enough to open the cuirass; also, there are wild dogs, with strong jaws. Against the lighter-bodied predators, they are safe enough.

Hence, owing to powerful enemies, they frequent deep burrows, from which they shyly venture forth, prepared to snap into the defensive ball. This little more than fair protection appears to account for the lack of spread of such armor among other mammals, unrelated. It is not nearly as effective as spiny covering, which, as has been noted, has developed among various unrelated kinds.

One armored type of South America is a fair success, and that is the giant armadillo. But that living cyclone is a sort of hangover from prehistoric times, when among cumbersome creatures armor was *armor*. One of the prehistoric armadillos, which was of huge size, had a tail terminating in a great ball of bone, the most fearsome war club the world has ever known. The modern giant armadillo, inoffensive in its feeding as a digger for ants or succulent roots, or mopper-up of carrion matter, retains an example of early try-out of armor *plus* weapons, for this species has claws like a garden scythe. This remnant of strenuous times among uncouth giants illustrates early attempts to exist, but the battle in that dim past was lost, despite fantastic provisions, by the upsetting of climate and surface conditions in this world of changes.

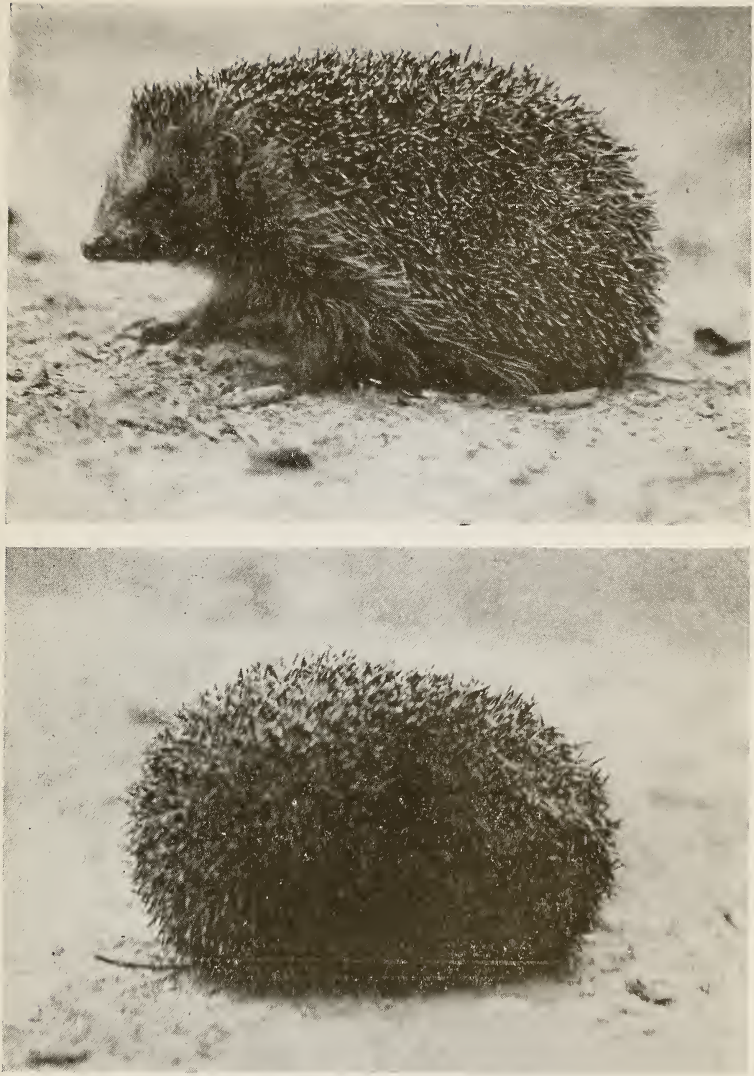
The best modern armor among mammals is to be seen with the pangolins of Asia and Africa. In form they are like big lizards, three to six feet long. Their covering is composed of big, overlapping, shingle-like plates from head to tail, of a horny substance so tough they resist the claws of the leopard. Moreover, the pangolins are able to fold their length into a circular coil held taut by such muscular power that no enemy can pry them from this compact form.

Even among the smaller predators, which in turn are attacked by the larger flesh-eaters, peculiar defenses have come into being. The skunks are star examples. New and Old World members of their clan utilize nauseous fumes to repel an enemy. It is a device recently tried out by man, and with his scientific ingenuity, has expanded to devastating possibilities.

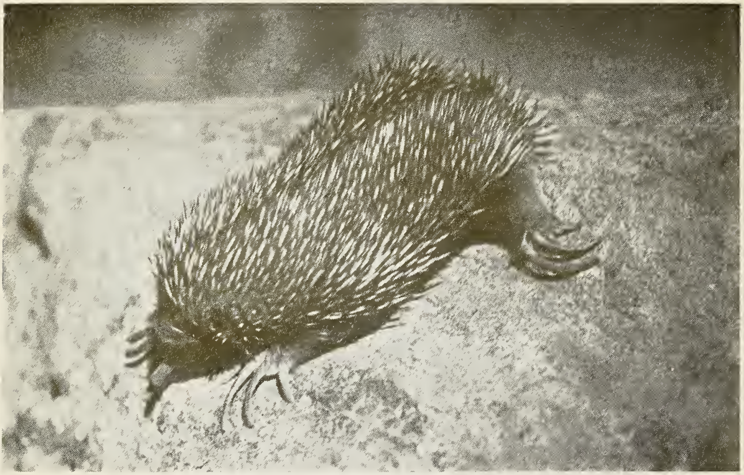
CHAPTER IV

THE LIVES OF BEAVERS AND THEIR KIN

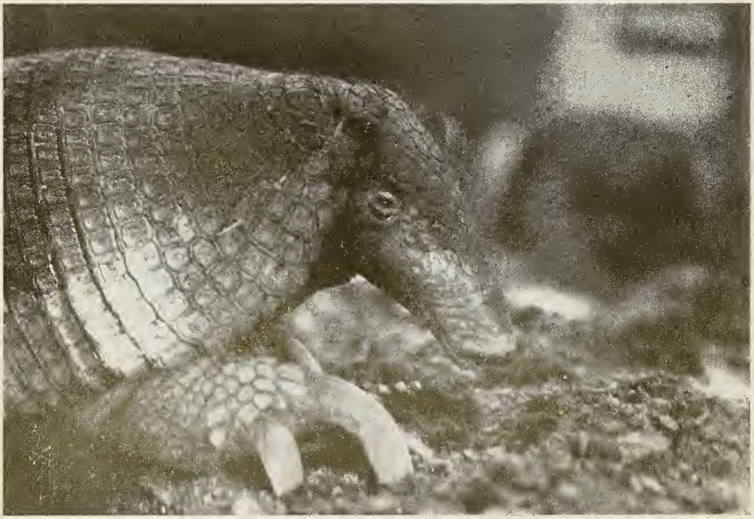
SOCIAL habits of mammals offer many points for study of how wild creatures carry on with ways of warning or intricate toil to protect their lives and rear their young. The most interesting are to be found among the more lowly orders, and the rodents offer fascinating observation. Here are gnawing animals, the greater number of small size. All are characterized by an enlarged pair of front teeth in upper and lower jaws. These are the incisors, chisel-like members, with particularly hard enamel on their front surface and continuously growing. This growth is to replace wear from use as tools, in obtaining food which is often of hard character, cutting the animal's way through hard surfaces in selecting shelter, or cutting materials for building homes. Animals with such teeth are the rats and mice, lemmings, squirrels, woodchucks or ground "hogs," prairie "dogs" and beavers.



European Hedgehog. It has many allies with spiny protection, which also exists among other unrelated animals. The lower figure shows how a hedgehog rolls into a ball when attacked.



Australian Echidna. Most lowly of the mammals, laying eggs, but rearing the young with milk. Remote in classification to porcupines and hedgehogs, but having a similar spiny armament.



Giant Armadillo. Remnant of the prehistoric, when many animals were armored. The modern armored mammals are rather scant in number of kinds.

The prairie "dog" is really a heavy-bodied, short-tailed ground squirrel of the Great Plains of the United States. Its mode of life presents unique slants in the fight to live. There are episodes carried on systematically, in large and orderly colonies. The burrows may extend over the plains for miles. They descend into the ground almost vertically and vary in depth from ten to fifteen feet. Thence they turn horizontally to about an equal length. Branching off from the horizontal burrow are nest chambers and excavations for storage of food. The nest chambers are bedded with grass.

The labor expended by a pair of prairie "dogs" —the size of a small woodchuck—in building such a burrow, with its attendant chambers, is skillful and prodigious. Soil is loosened by the diggers' front claws, shoved backward to the hind feet, then shoveled toward the surface, the animals alternately going forward to dig and working backward as load after load of loose material is worked upward to be cast out. Much of the exhumed soil is left around the entrance of the burrow to form a mound. This is firmly pounded into form by the workers' butting it with their flattened foreheads, the movements of their heads as fast as the cadence of a riveting machine. The height of the mound is important. It prevents rains from running into the burrow. With such a home the prairie "dog" is safe from the digging operations of coyotes, badgers and skunks. The sinuous prairie ferret, however, can enter such excavations.

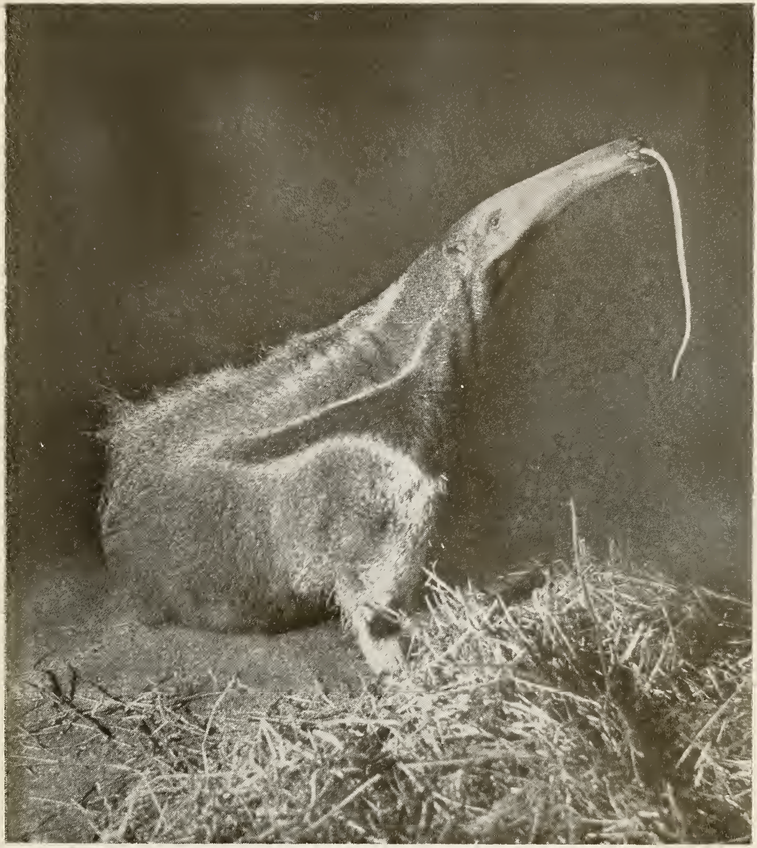
With enemies liable to be about and members of the colony obliged to forage for roots, seeds and grasses, a system of watching is maintained in a prairie "dog" town. Scattered here and there are sentries, sitting erect and alert, often shifting positions to keep a lookout on all sides. There seems to be an understanding about relief of sentries. An animal will drop down and wander off to feed, and almost simultaneously another lookout takes his place. The alarm from a lookout is a staccato chatter and there is a streaking of the colony to their burrows. The sentry is the last to retire and may only go down as far as the "sentry ledge." This is a shelf, excavated from the side of the main burrow a yard or so beneath the surface. Some of the retreating "dogs" may not go any deeper. That ledge is a listening-post. When the sentries peek out to see if danger is past and are satisfied there is no further cause for alarm, there is a prolonged squeal, carried from one to another. This is followed by a cautious emergence from all the burrows.

The colony hibernates through severe winter weather and there may be periods of weeks when the snow over the whole area of a great system of mounds of thousands of animals is unmarked by footprints. The burrows are so deep that no frost can penetrate to the nests.

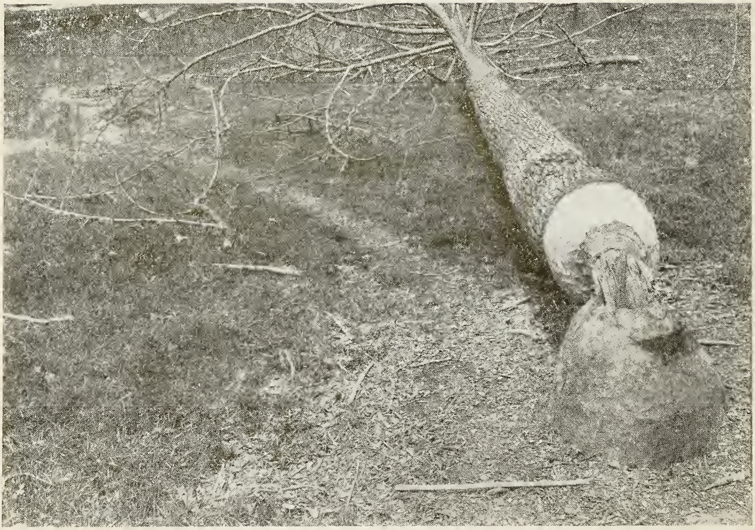
There is no truth in the alleged friendly triangle of rattlesnake, owl and prairie "dog." The two former are camp followers, taking advantage of abandoned burrows on the borders of a settlement. The owl builds its nest in the listening-posts and the prairie rattlesnake coils in such places, commonly to digest a meal—of young prairie "dogs." The deep, deserted burrows are snug hibernating places for many snakes. Other creatures likewise take advantage of them, such as wild rats and mice. They are ideal places for breeding, or to pop in when pursued by the prairie owl. Hence community life goes on. It is one of watchfulness by all hands.

The beaver's busy life is even more interesting, for here is an animal that adapts itself to the seasons, that is constantly busy in its skilled operations of an animal engineer. Beavers are semi-aquatic rodents. There are species in North America and one in Europe and northern Asia. They are particularly large for rodents, attaining a weight of sixty pounds. The tail is flat, like a paddle, but its use in swimming is mostly in steerage for diving or ascending, like the "elevators" of an aeroplane. The feet are the main swimming organs, the hind pair being strongly webbed. These animals live in moderate-sized colonies along streams, or streams widened into areas like lakes, such extensive surfaces of water being produced by the engineering work of the beavers, which shelter in large houses rising like big mounds from the water. The house built by a beaver colony may be as much as twenty feet in diameter, rising six feet above the water.

When a colony becomes overpopulous some of the younger members break away to start a new



Tropical American Anteater. The world's abundance of ants and termites produced the evolution of such specialized types with ant-catching tongue.



American Beaver. A constant worker and animal engineer.

Beaver Cutting. The big tree has been brought down by chisel-like teeth to obtain materials to build a dam. Note the beaver-made path from the stream.

settlement. They may travel a considerable distance up or down the stream until a place is selected that satisfies them. Then there is the beginning of a sequence of engineering operations as orderly as if planned by human mind. Some parts of the stream are shallower than others; mounds beneath the surface, and such spots, are investigated by the swimming and diving beavers. A sandbank may be selected and upon this they set to work. Its sides are built into better symmetry. Water-logged sticks make good retention and over these are deposited small loads of mud, many loads, carried on the forefeet and braced with the chin. The result is an island that is to be the base of the house, or "lodge" as woodsmen call a beaver home.

The really hard work is yet to begin. There are many trips among the saplings bordering the stream. Here the powerful gnawing, or incisor teeth come into play. I have watched beavers cutting down small trees, three inches in diameter, and each tree tackled by a single beaver falling within ten minutes, with the chips lying around as if from hatchet work. Such trees are gnawed into sections three to five feet long and stripped of the finer branches. Then the sections are towed to the mud island, where, to the human eye, they seem to be dropped pell-mell. As the work progresses and days go by and the towing continues, the house assumes form. This is indicated by the tree sections and smaller saplings pointing toward a center. Also, there are trips with the finer branches, utilized in a sort of weaving process to prevent slipping of the heavier, piled-up material.

A new phase of work develops—the loads of mud again. The crevices are filled and the structure plastered. Then come additional outside boughs and more lacing material. Here is a commodious, mound-like house being made ready for the colony. Inside is a circular living-shelf, and low on the slope a rounded entrance. As the work goes on the significance of the level of that living-shelf or second story, and the level of the entrance, will soon be seen. Completed, the house is of great strength. Even human hands would have great difficulty in breaking into any part of it. Built of successive layers, it is weather-proof.

Activities shift. Finishing touches go on around the house, with an occasional beaver doing this or that, but the main gang of workers moves downstream. The gnawing of saplings is carried on with greater energy. There is much diving with the longer cuttings, which are anchored in the mud and woven together with pliable branches. These activities are producing the base of a dam across the stream. The object is to make deeper water in which to dive from enemies; also to submerge and hide the entrance to the house.

As the dam rises from the water, two kinds of work are going on. Mud and water-soaked leaves are being worked into its foundation. Above the water there is much tugging and hauling of what, compared to the size of beavers, looks like astonishingly heavy timber. Large forest trees, two feet in diameter, are assailed by a group of workers, gnawing on all sides. The symmetrical cutting assumes the outline of an hour-glass, with greater indentation on one side than the other. The tree, thus balanced, stands until the last fibers to support its weight give way. After it has fallen, and its fall is usually toward the water as it may have been more deeply indented on that side, its heavy upper structure is selected for the rising part of the dam.

It is not unusual to see sections six inches in diameter and a yard long on the top of the dam. They were towed out by incisor teeth grasping some projecting part and thrust into place by a shove of the head. With the dam completed and the water of the area much deepened, the living-shelf of the house remains above the new level.

Workers must eat, and considering the tasks performed by beavers, it would seem that they should be heavy food consumers. They are, but their diet is of the simplest kind. It consists almost entirely of bark. Poplar, willow, birch and aspen furnish the favorite food barks. Much of the timber on a beaver house and dam has been gnawed clean of bark.

In a settled beaver colony, the work shifts according to the seasons. Spring is a busy time, as ice and freshet damage to the house and dam must be repaired. Torrential rains in summer may give trouble with the dam; and the arrival of litters of young may bring the need of remodeling or enlargement of the house. Autumn is particularly busy. With the falling leaves all adult members set to work gathering a winter's supply of food-wood. This is in the form of six- to eight-foot saplings and a long pier of them is built out from the house. Such food piers vary in length from twenty-five to fifty feet and six to eight feet broad. The lacing of food-wood is carried down to the bottom—a very important arrangement. It provides plenty of bark to be reached beneath the ice when the water is heavily frozen over. The finishing touch of winter preparation is replastering the house, to make it cold-proof.

When the thrift of the beaver, the prairie "dog" and their numerous kin is considered in the making and maintenance of homes without hands, the carefree apes and monkeys appear to check as one of the weaker links in the strife to carry on.

CHAPTER V

AMONG THE BIRDS

MY first experience with birds, stimulating thought about the feathered tribe, occurred when I was but a lad and rambling over a weedy meadow, the growth knee-high.

There was a sound of a bird just ahead of me—among the reeds near my feet. It was like that of a bird which had been restrained. Looking down I saw a brownish bird, with drooping wing. With common inclination I stepped forward to pick it up.

The bird made an effort to keep ahead by hopping and fluttering, but always with the dragging wing. I reached forward to grasp it, but it evaded me, changing its struggle to elude my hand by turning at a right angle. After I had pursued it well across the meadow I was astonished to see it rise and fly away in quite normal fashion. It was then that I had a thought the bird had fooled me and told my experience to a teacher at school. Natural history was not among our studies, but this teacher was a kindly soul who liked to take long walks and talk about outdoor things. I had gone along with him in the past as he hunted for cocoons of moths. He set me right on the bird episode, telling me that I had disturbed a bird on or near her nest among the reeds and her antics had been to lure me from it so I wouldn't find the nest. He went on to say that birds lured cats, weasels and snakes from their nests, and sometimes were not quick enough to evade the dart of a serpent head. This, he said, had been seen by persons inclined to form snap judgments in outdoor occurrences, hence the story that snakes could hypnotize or charm birds so that they were powerless to fly. This I was to witness years later when I was aware of the habits of both actors.

I watched the episode from the porch of an old plantation house in Georgia. The conditions were ideal to see every part of the action as it occurred in a big liveoak with horizontal boughs, from the thicker parts of which gray Spanish moss hung in streamers. Extending from the tree twenty feet or more the boughs were bare, but toward their branching parts there was luxuriance of glossy

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foliage. Among this, all day, there would be variety of bird sounds, and the darting forth of birds in search of insects. It was spring and a busy time for the clan, as they were rearing young.

A chattering broke out, a scolding chatter that grew raucous. Looking into the tree I saw the reason, a shining blackish serpent, fully six feet long, making its way out on a big limb. It was easy going for the snake, there being no need for balancing, just a bit of draping, an undulation to one side or the other.

Just ahead of the snake was a bird, with quivering and dragging wings as if benumbed and unable to evade the pursuer much longer. The snake was gathering an anterior loop for a dart at the bird; then another loop formed, behind the first. The bird made what seemed like an agonized hop, but I could see that it carried the tempter beyond reach of those striking loops. What surprised me was the direction in which the bird was luring the snake. It was toward the thick foliage, the direction of its nest; and the reptile, a black ratsnake, as commonly called chicken-snake, feeds upon both rodents and birds, as its dual names imply. Young birds in the nest are particularly delectable.

But there was logic in the guidance of the enemy, for ahead was the branch of a scrawny, encroaching tree which brushed the bough of the liveoak. Onto this the half-crawling, half-fluttering bird made its way. The snake's appetite was whetted. The bird looked tempting, and while bothersome for the moment might soon be caught. But I had doubts that the reptile would follow to the springy branch of the smaller tree. It would mean a long reach with danger of the branch bending to such an angle the climber would slip off. It followed, however, reaching nearly a yard forward, then placed the weight of its body on the limb and went ahead. The limb sagged and in bowing slipped from contact with the liveoak.

Rather breathless I expected to see a bird ruse that dropped a snake out of a tree; but nothing of the kind happened. The snake knew what it was doing; in danger from a fall. There was enough of its tail around the major bough to have supported it and it had looped through the more slender branches ahead to keep from slipping off.

Anteriorly it threaded its way more securely and finally made its way upward to where the branch thickened. The reptile's head weaved from side to side, looking for the prey; but the bird was gone.

Just how keen was the ingenuity of that bird is problematical. While the snake managed to make its way from the larger to the smaller tree, it would have been difficult to have respanned the trees over the avenue of a sagging branch. It was clearly seen that the bird lured the snake from the nesting part of the liveoak, and its actions might have led an uninitiated watcher to think, if the snake had managed to grasp it, that the bird was hypnotized. That such luring birds may miscalculate the dart of a snake's looping neck is probable. In that same Georgia region, where snakes are numerous, I saw other instances where birds seemed to be taking chances of being caught.

My interest in birds has been of rather casual nature, although keen at times in watching their nesting habits. One incentive comes from their descendence from reptiles—and intensive study of reptiles has been a specialty of mine. In the age of the dinosaurs, when some of these reptiles, large and small, acquired the habit of running in rearing position, hind legs grew longer and specialized for such antics—and front limbs relatively shorter and weaker. Races of queer-looking creatures were evolved, with long, stalking legs and anterior members degenerated to little more than a pair of clawed, hand-like appendages sprouting from the breast. Necks grew longer and among these freaks were forms like a featherless ostrich with reptilian tail.

Just when feathers appeared among these midway types of changing life, is a problem. Fossil remains are too fragmentary to tell the story. But during the Jurassic period feathered forms existed, as is shown by discoveries in 1861 in quarries in Bavaria, where many fossils have been found. The indications of a true bird thus discovered were in the form of bones and the imprint of a single feather. Piecing the ancient bones, the creature was deduced to have been the size of a chicken. The head had no horny beak, but was pointed and provided with teeth. Further search cleared the story. Remains came to light with enough imprint of feathers to show that ancient birds had a long, fleshy tail covered with large feathers. Clawed fingers protruded from each wing. The first discovered birdlike being was scientifically named *Archæopteryx,* meaning "ancient wing."

Just when nest building started among prehistoric birds is a point not yet cleared up. It was not indicated among reptilian ancestors. Reptiles dug holes and buried their eggs or crudely scraped debris into heaps to cover them, or to induce a temperature in such rotting medium to hasten incubation. The lives of reptiles up to and including the modern kinds have never indicated skillful nest building. Yet birds, which have descended from reptiles, have swung into habits of variety of skill in building nests—even those of form apparently coupled with ancient ancestry. Thus the hoatzin, of the American tropics, builds a nest in the trees, although this hangover of early bird life shows traces of reptilian relationship in structure and habits. Before the young are able to fly they climb about near the nest by means of claws on the wings.

There is sort of a hodge-podge of habits among birds and reptiles, showing relationship and flashbacks in habits among the former. Among reptiles the nearest approach to nest builders are the crocodilians. A female alligator, for instance, will scrape together a big mound of forest debris and water-soaked leaves. I have seen mounds ten feet in diameter and a yard high. There is no skill in accumulating such a mound, only scraping of the material together. The eggs are embedded in the mass, which, like a compost heap, develops a higher temperature than the air and hastens incubation. Crocodilians are directly related to ancient reptiles and their clan has extended through the ages with little change.

There are modern birds with such mound-building habits—birds which depend upon eggs to be hatched by heat generated in decaying vegetable matter and have little more to do with the rearing of the young than reptiles, as their young are able to fly after breaking from the egg. Such are the Megapodes, more than a dozen species, scattered through the islands of the Pacific from the Philippines to Australia. In appearance they are not unlike small turkeys. The legs and feet are very strong, adapted to scratching and digging. If the mound-building, artificial-hatching habit of the Megapodes is a hangover or flashback from reptilian ancestors, it is a trait gone somewhat mad, as these birds build mounds of enormous size in the jungle. Sir Richard Lydekker records a mound sixty feet in circumference and eight feet high. From its appearance the birds had worked on it for several years, using it in communal fashion during the egg-laying period. Lizards had dug into its margins and deposited eggs as the soft, warm medium was ideal for reptile hatching.

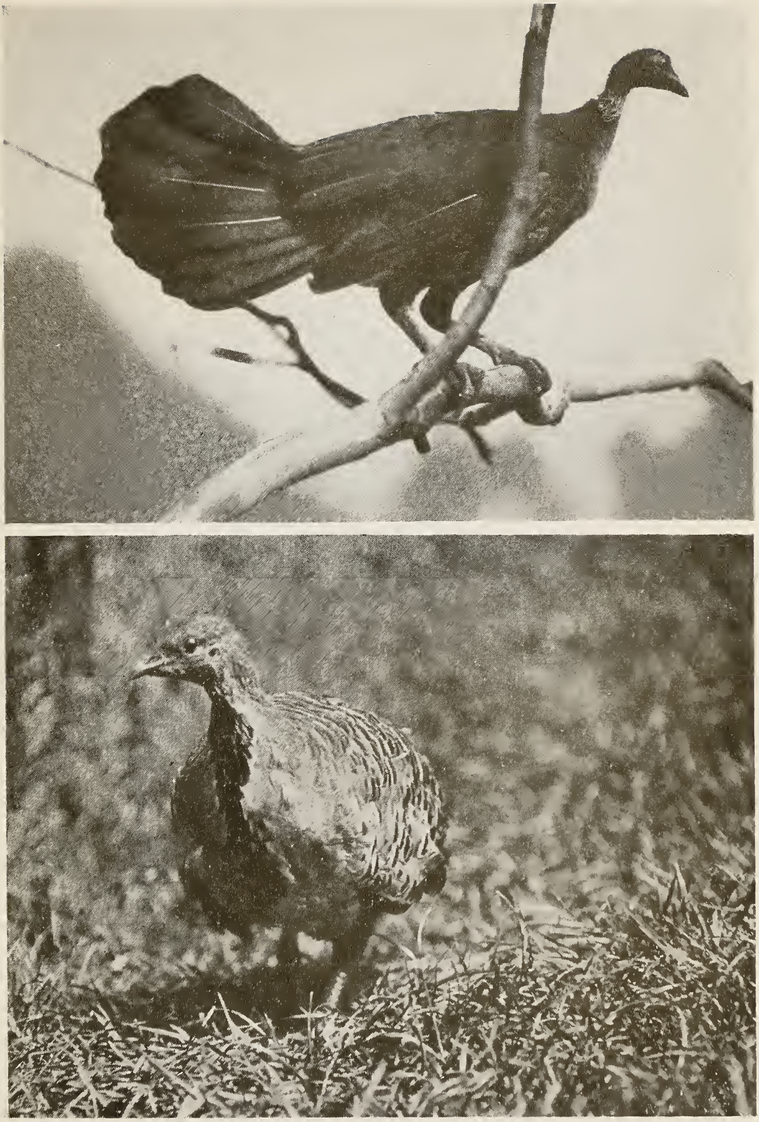
Even more astonishing is a description by the naturalist F. A. Pouchet of one of these communal hatching mounds one hundred and fifty feet in circumference, the sides eighteen to twenty-four feet and the perpendicular height twelve feet. Pouchet has written: "Compared to the size of the bird, the dimensions of such a mountain are almost prodigious, and we ask how, with its beak and claws only for pickax and entire means of transport, it contrives to get together such a mass of material! . . . The comparative size of the animal being very difficult to arrive at on account of the variety of its altitudes, if then we take the weight as a standard, we find that a Megapodius weighing rather above two pounds sometimes raises its tumulus more than ten feet in height; now, as a man weighs on an average about one hundred and thirty pounds, he must, in order to build a structure corresponding to the nest of the bird, accumulate a mountain of earth which would be almost double the height and the bulk of the great pyramid of Egypt!"

Another Australian bird, the brush turkey, has similar mound-building habits, but with this species grass and leaves are gathered in enormous mounds, the materials carried by the builders grasped by the feet. The method of hatching the eggs is the same as that of Megapodius, the reliance upon heat generated by compost, fermenting vegetable matter. And again with this bird the young hatch completely feathered and ready for flight.

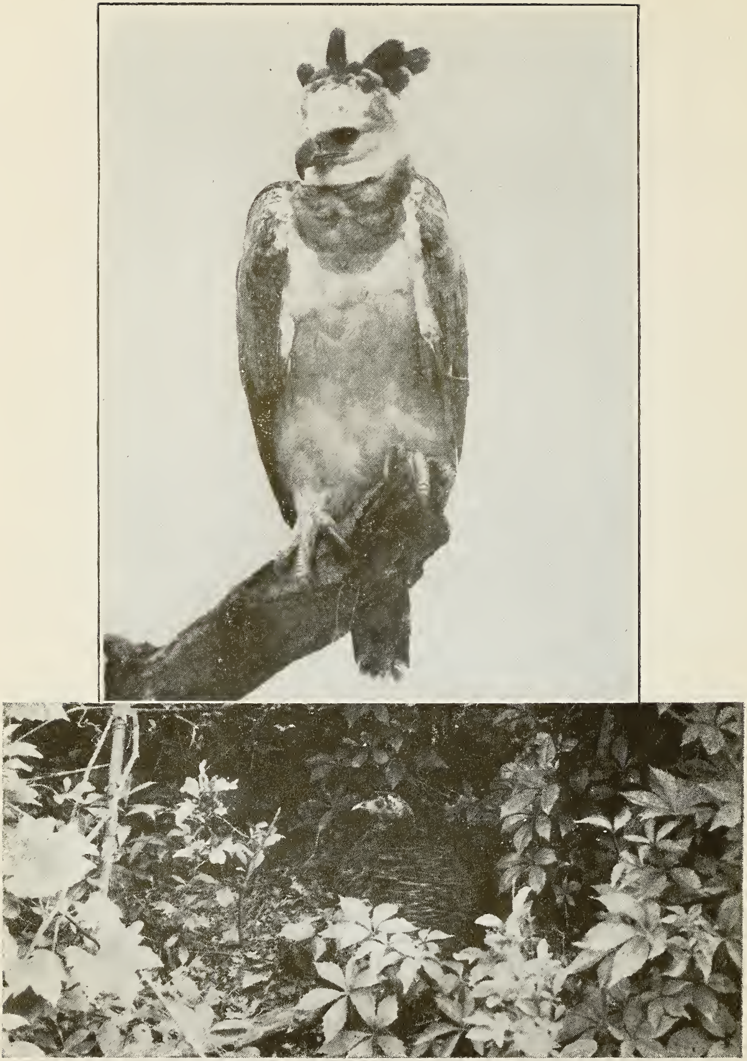
I remember the labor of a pair of these birds liberated in the Zoological Park in a dense grove of high rhododendrons. The ground was carpeted with the fallen leaves of the shrubs and the leaves were solely used as mound-building material. We marveled at the symmetrical hillock which rose from the constant work of the birds.

The power of flight, hence the ability to leave the ground when pursued by terrestrial enemy, the aerial nesting habits of the greater number, or if ground-building the skillful concealing of nests, have given birds an advantage over mammals, hence their greater superiority in numbers over other warm-blooded forms of life. Another advantage is the rapid development of young and early ability to fly with the speed of the parent. The thrushes, for instance, attain mature size and power of escape by flight within a month from the time of hatching from the egg. I have noted the hatching of broods of robins and the young were of parent or flight size within twenty-four days.

Among aerial types of nests there is wide opportunity for the study of skill that is possible in the construction of intricate homes without hands. Even the most dextrous human fingers would find it extremely difficult and make a long job in duplicating structures of relative size similar to the divergent nests of a magpie, thrush, swallow or



Mound Builders. The upper figure is a Brush Turkey of Australia and the lower the Ocellated Megapode, also of Australia. Birds of this type build huge communal mounds in which eggs are buried and incubated by heat of decomposing vegetation. The young can fly immediately after hatching.



Widely Divergent Birds. The upper is the Harpy Eagle of tropical America, a powerful predator, preying largely on monkeys. The lower figure shows protective resemblance of the shy Wild Turkey.

humming-bird. Yet these perfectly woven or molded structures are quickly completed, and with most birds discarded after a single occupancy. The fish-hawk or osprey is among the exceptions where a nest is used year after year, but with such types there is prodigious labor in carrying sticks of many sizes, weaving them into a platform six to eight feet in diameter and shaping the crater-like interior to shelter the young. Such a nest may contain a wagonload of material.

There are birds which build colonies of nests under conditions shaping to the safety of such communities. The most convincing demonstration of planned communal life I have seen was in Honduras and Costa Rica, where in great ceiba trees were the colony nests of the tropical orioles or caciques. The nests are bag-like, as much as six feet long, and there may be fifty or more in a colony, swaying in the wind like sacks, far out on great horizontal branches. From a distance they look like strange fruits of great size.

Commonly, as I saw these colonies, there were big spherical nests of tropical wasps on the same branches. My field-glass showed the circling of such formidable insects in association with the birds as they made their trips to and from the nests, each oddly different kind in seeming harmony with the labors of the other. The principal enemies in that area—as potential nest robbers—were ocelots, tropical raccoons and six-foot tree iguanas. A raid on the nesting colony would have involved passing the nests of the great wasps, and, as I have found them, they are infuriated by the slightest incident beyond normal. Thus it seemed clear that the caciques had fiery watchdogs to guard their community.

With the smaller tropical birds we saw nests not far overhead, in small trees encrusted with lichens and parasitic growth. But an inspection of the tree-trunks showed stinging ants wandering partially under cover. Even a stick rubbed over the matted surface brought these insects raging out. There is no predatory animal in the tropics without the keenest respect for the agonizing stings of such alert insects.

In places where enemies are rare, such species as the sea birds may make no pretense to build a nest. Eggs are brazenly laid on open rocks or hollows in the sand. The so-called "bird rocks," bleak places, swept by ocean winds and with the thunder of the surf near by, are areas of such bird habits and there are many of them scattered over the world. That such habits are not neglectful in the care of young, is shown by the enormous thriving flocks of such kinds of birds.

Thus do nesting habits vary. In areas of danger there are adaptations to meet it. Nest construction and placing also depends upon the early helplessness of hatching birds, or young fully covered with immature feathers and ready to follow the mother immediately after hatching. Such are the young of the fowl-like birds. Their nests are little more than crude incubating hollows and the young are protectively colored to blend with surroundings.

Mimicry among birds is to be widely seen, and among unrelated kinds. Here is a tryout along lines of protection that is faced with many inconsistencies. Among the lower forms of life, the invertebrates, it assumes amazing extremes in the simulation of leaves and sticks or the voluntary covering with debris to thus stalk about in disguise. The main point of inconsistency to be noted is that the most pronounced forms of mimicry, while clearly and constantly utilizing methods to avoid detection, do not seem to profit thus in increasing their numbers. With birds, as among insects, the most brilliantly colored kinds are as abundant as the others.

Writing for the *Bulletin* of the New York Zoological Society, in 1937, Ben East, Nature Editor of the Grand Rapids *Press,* presents some experiences with birds of marked protective coloration. Speaking of a whippoorwill, covering her eggs on the forest floor, he says: "So perfectly did she match the dull hues of her surroundings, so closely did she resemble a weathered gray-brown knob, that I stood within two yards of her for fully ten minutes, knowing almost certainly that she was near at hand and within plain sight, but utterly unable to separate her outlines from the woodland floor." The bird was finally located, close to the observer's range of vision, and was photographed. The article continues:

"I still recall that mother whippoorwill as the most perfectly camouflaged thing I have ever searched for upon the forest floor.

"Next to her, I believe I must rank a nesting woodcock upon which we spied one cold windy day in early May. We made pictures of the bird, brooding in her queer pose, with our cameras less than a yard from her. She sat motionless, unflinching, never betraying her presence by the slightest movement. Not even an eyelid flicked down.

"Nor was her confidence unwarranted. The warm buff and amber, russet and black and gray tones of her mottled plumage matched almost perfectly the colors of the dead leaves and woodland litter around her. Not even the dull greens and reddish-browns of a thick carpet of wintergreen all about the nest tended to betray her.

"A hand brought down to within a foot of her head failed to shake her courage and apparent belief that she was undiscovered."

By some influence, instinctive or instilled by the parent, the chicks of such protectively colored parents, the young themselves of dull or mottled hues, will scurry into the leaves and "freeze" or remain motionless upon the mother's alarm call. With cessation of motion they seem instantly to disappear, but the mother takes no chances. If it is her suspicion that an alert enemy has noted any commotion, she drags herself from the scene with what looks like a broken wing—the common lure to the enemy of ground-nesting birds caring for their young.

Thus does mimicry in various phases exist among birds, markedly pronounced with some, fairly evident in others, existing only among the females with many. Within the legion of birds there is a great number of species with no indication of it.

With the power of flight among by far the great majority, with their skill in nest-building and specialized care of the young, also the relatively short period of helplessness of the young, birds have a lesser problem to maintain their numbers than mammals. Not alone does their aerial mobility enable them to shift from unfavorable areas, but the mysterious power that guides them in migration enables them to travel unerringly thousands of miles in evading changes of seasons. They have watching enemies on the ground, which through long passing of time have trained their wits to capture them as prey, and there are hazards in the air from predatory members of their own orders—the swift birds of prey. Yet the bird population of the earth remains numerously evident almost everywhere, even in great areas long claimed by civilization in which terrestrial mammal life has become scant or almost disappeared.

CHAPTER VI

DOWN THE SCALE TO THE REPTILES

IF one could select from among the many genera of lizards an oddly different type here and there, then set up a number of these forms, say fifty of them, in motionless posture, the effect would be of a toy-shop with models produced by fanatic designers. There would be forms of grace, of extreme ugliness, bizarre forms and others in such eccentricity of knobs and spikes they might appear as almost impossible to represent living beings. There would be a riot of colors and variety of patterns.

Lizards range from tiny burrowing things no thicker than a goose-quill and a few inches long to six-foot iguanas of the American tropics, the powerful monitors of Asia and Africa and the extreme in size—the Komodo "dragon," a monitor growing to a length of twelve feet and a weight of three hundred pounds. There are about twenty-five hundred kinds. The larger are much in the minority.

Lizards have many enemies. The flesh-eating mammals feed upon them, many birds search for them as part of their diet, there are cannibalistic members among the lizard races themselves. Even the larger kinds are attacked by beasts of prey—or their eggs are dug up and devoured by small animals. Snakes are common enemies of lizards.

Living thus in a dangerous world they have acquired all sorts of protection, by evasion in many sly ways, by astonishing forms of mimicry and camouflage, bony scales, formidable spikes, strong jaws, lashing tails, ability to burrow with great agility or literally to "swim" into and beneath loose sands. Some can run at bewildering speed; a few at such speed that they can traverse the surface of water without sinking. Some Malayan species of unrelated families, geckos and tree "dragons," have approached close to the power of flight, as they have scaling planes between the fore and rear limbs. They can make long, soaring leaps from tree to tree and guide their progress. Of the two groups of soaring kinds, the little tree "dragons" are the more elaborately provided, the soaring planes being spread by elongate, dilatable sets of ribs.

One defense of lizards, more or less evident according to group, has aroused conjecture among misinformed persons and produced the familiar story of the "glass snakes." These are true lizards, legless species, of which there are a number. Such creatures resemble a snake in outlines, but are stiffer in motions; they have ear-openings and movable eyelids, which are lacking with snakes. The "glass snakes," of both the New and the Old World, have a relatively longer tail than snakes; in fact, this is about two-thirds the reptile's length. From above there is no indication of where the body ends and the tail begins.

The technique of a "glass snake" in escaping from an enemy is, when grasped, and this is usually by some part of the tail, to part with that organ instantly. This is done by specific development of the caudal vertebræ, a provision for deliberately casting off the tail or a part of it. The vertebral joints are long, brittle and readily snapped. As the tail is cast off the scales close over the stump. It is a neat and instantaneous feat. Soon after, there is a stimulating action set up at the spot where the appendage has been cast off and a new tail starts to grow.

With this background noted, suppose that a "glass snake" is pursued and attacked by a serpent enemy or grasped by a hawk. The tail is snapped off and instantly becomes an object of strenuous activity. It twists and snaps and may even part into respectively writhing sections. The enemy concentrates on subduing this object or objects, while the shortened owner slips away to hide—and grow a new tail.

Attacked by a human, who may strike a blow with a stick, a "glass snake" may apparently be shattered into pieces. Thus has arisen the legend that these "brittle" creatures may be broken into fragments, which, if left alone, will writhe their way together, sometime around "sundown," in a reconstruction of the original form.

This voluntary parting with tails is also common among lizards of the extensive family *Iguanidæ,* also among the skinks and geckos. I remember the sly antics of a gecko I was stalking among fallen palm leaves in Algeria. It was not very quick, but just elusive enough to keep ahead of my hand. Finally I made a slap at it, but it ducked forward and my fingers caught its tail, which wriggled from my grasp like something gone mad. The tail snapped and hopped among the debris, raising such a commotion that for a few seconds my attention was focused upon it. When I looked for the gecko it was gone. Turning over the fan-like leaves I found it hiding not a yard away. Presumably it had quietly crept under a leaf while my attention had been attracted to the tail.

The tails of some of the stronger lizards are used for other defense—with some as weapons; among others entanglements to burrows. The spike-tailed lizards of Africa (*Zonurus*), which are spiked all over, but with particularly formidable tails, dig burrows and crawl in headfirst. The tail, with its bristling, bony armament, is transversely bent in the burrow to form an impassable entanglement. No snake or small carnivore would find it worth while to tackle such an obstruction. Such protective tail structure exists among others besides *Zonurus,* lizards of Old and New World families that are not allied.

A common defense with the tail among the larger lizards is to deliver lashing blows from side to side. The whip-like lashing of the iguanas or the really formidable smacks of heavy-bodied monitors, show how lizards' tails are put to use.

Then again there are prehensile tails to avoid falls, among arboreal kinds. Such are seen with the African chameleons, slow-moving reptiles that are protectively colored. Although slow in motions the chameleons are provided with something exceeded by no other kind of lizard. They have a tongue of many folding segments like the structure of a collapsible drinking-cup. This has a sticky tip and when "shot" or extended is as long as the owner's body. Braced by the prehensile tail, a chameleon slowly wends its way, its goggle eyes surveying its progress, alert for insect prey, which it unerringly "shoots" and captures.

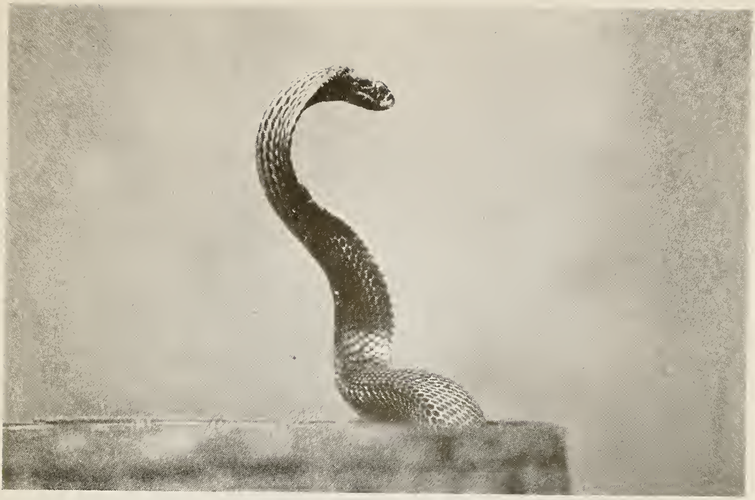
Protective coloration and protective form hint of the variations among lizards. Simulation of coloration to soil, bark and leaves is common, but bodily form to blend with surroundings has been carried to a marked extent. Spiny forms are to be found in desert regions where debris of spinous plants litter the surface. Some of the larger geckos have frills of bark-colored skin, which fold against a tree-trunk when the creature rests, so conforming to corrugations of the bark that the reptile is all but invisible. *Nephrurus,* a rock gecko, is gray and lumpy, with a ball at the end of the tail like a rounded fragment of the surface on which it lives. The horned "toads" of North America are protectively colored to an astonishing degree. I searched for, and with difficulty found, specimens in a desert area of curious hue which was coarsely sprinkled with fragments of black lava. The lizards were of the hue of the sand and all had a few black spots to match the fragments.

While snakes are a "recent" offshoot from lizard ancestors, they have changed their tactics of defense. In considering the defenses of snakes it is well to separate them into two groups, the fanged or poisonous and the non-venomous kinds. There is a curious similarity in actions. The former strike or bite with the full knowledge of power of their fangs and the effect of distress or terror upon an enemy, and the latter commonly simulate or bluff in behaving like poisonous snakes. Their actions indicate that a striking posture or biting may cause momentary recoil of an enemy, the latter instinctively cautious owing to some snakes being poisonous. A moment's hesitation of the intruder may enable an active, harmless serpent to make its escape. The art is overdone in some instances. There are a number of harmless snakes that flatten, widen the head, distend the body with air, hiss, or thus put up a bluffing show quite out of keeping with the average poisonous snake, which delivers its poisoned bite with no pretense of bravado, other than possible warning of buzzing tail or rattle. The tail-shaking has also been adopted by harmless snakes.

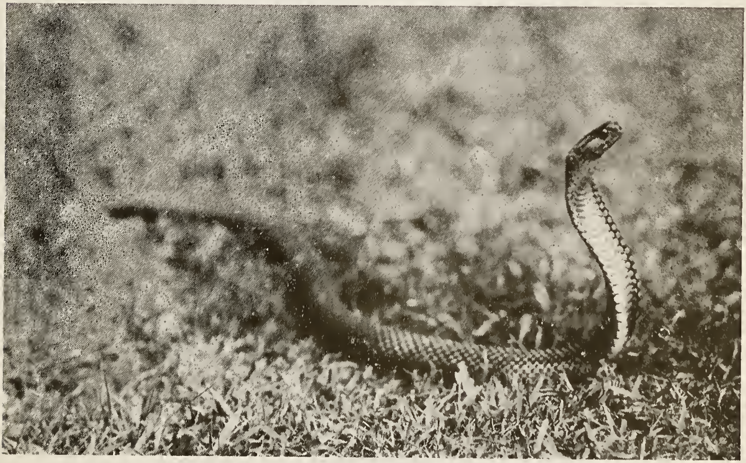
What are the enemies of harmless snakes? They have many. They are sought by birds of prey and by the smaller carnivorous mammals. Man is a highly potential enemy and snakes know it. I have watched cattle and horses walk past snakes and the reptiles barely moved, but when I approached them they glided in rapid flight. In the South I have guided a horse around blacksnakes or coachwhip-snakes sunning in the road and the reptiles remained where they were unless I swung out of the saddle. Then they were on the move.

Some snakes have acquired great speed for escape, many of the slender kinds gliding at the rate of a man at run. Others have wedge-shaped snouts and can quickly burrow. In Malaysia there is a genus of "flying" snakes, which have elongated ribs capable of great distension and flattening of the body. These are tree snakes and if attacked by hawk or arboreal mammal, drop from a branch, flatten, and go scaling off at such speed that not even a winged enemy can catch them.

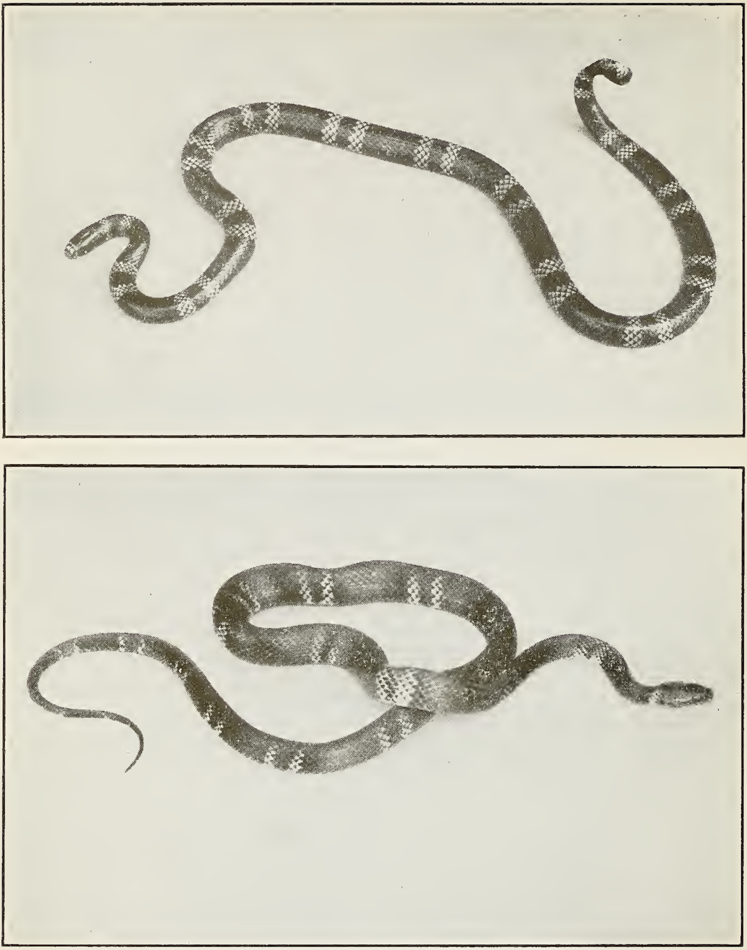
In the matter of making themselves look as fearsome as possible, four harmless serpents separated in habitat may be mentioned as representing many. One is the American hog-nosed snake, a stubby species seldom over a yard long. Unless close to a sheltering crevice it is too slow to escape by flight. When frightened it flattens the head and neck widely, thus intensifying its normally strong colors. It hisses and strikes (but with closed mouth). It is a far more alarming-looking object than the poisonous copperhead snake also found in its range—and which puts on few airs. If the



COMBAT POSE OF COBRA. Distensible ribs enable this deadly reptile to spread its hood and thus inspire fear if molested.



A HARMLESS CUBAN RACER. There are no cobras in the New World, but strangely enough the threatening pose, assisted by distensible ribs, appears among non-venomous serpents of this genus.



Mimicry Among Snakes. The upper figure is that of a deadly Coral Snake of Brazil. The lower is a harmless mimic of the same country. Both are ringed with scarlet, yellow and black.

hog-nosed snake finds that the bluff doesn't work, it feigns death.

The spotted ratsnake of northern South America *vertically* flattens its neck and weaves its head in threatening fashion. An allied kind of Brazil, six feet long, blows up the body until it is twice the normal size, then strikes with explosive hisses. In Africa, in the realm of the dreaded green and black mambas, which are tree cobras, are large and slender tree snakes which dilate the neck, in mamba fashion, but attract particular attention to the action as the neck is barred with colors that become vividly apparent when the scales are separated in the dilating action.

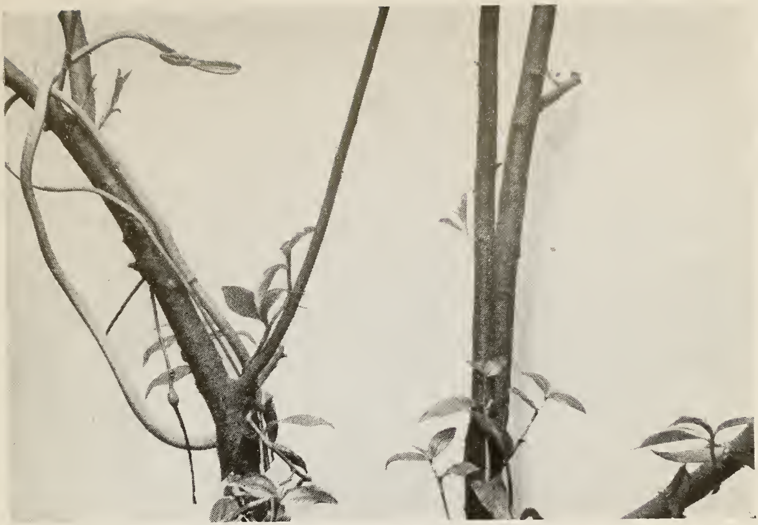
Aside from pretending by their actions to be dangerous, there is another kind of mimicking of poisonous serpents by the harmless kinds. This is in similarity of markings and unique colors. All through the great stretch of tropical America, where the deadly fer-de-lance and its numerous fanged allies are to be found, there are harmless snakes so strikingly similar in colors and pattern that even the specialized scientist needs a critical look to distinguish between venomous and non-venomous. Even more widely variant as imitators are those ringed in wide or narrow combinations of scarlet, yellow and black, like the poisonous coral-snakes. Such an array of colors, and in rings, is restricted among snakes and these harmless masqueraders are thus all the more remarkable. Moreover, they have taken up peculiar actions of the dangerous coral-snakes, of twisting and snapping from side to side.

It is a common belief among misinformed persons that the forked tongue of a snake is a stinging organ. The tongue of all snakes, both poisonous and non-poisonous, is a harmless organ, highly developed to detect by taste, in its waving flashes, the odor of prey, or gland odors exuded at mating time. Thus it balances for the loss of normal power of scent among snakes.

It appears that not only humans may associate the waving forked tongue of a snake with something that is dangerous, but the serpent thinks it may use the unique organ to intimidate other enemies. I have seen the action among many unrelated snakes, the tongue used in different ways. It may be waved slowly up and down, which is more evident where the base of the organ is red and the fork black. The effect is sinister. Other kinds project the tongue straight out, the forked part widely spread, the organ quivering so it scintillates in the light. Tree snakes may project the tongue with the forked portion folded. The effect is like a black prong or sting. The most exaggerated gesture of the latter kind I have seen was of a slender South American tree snake about five feet long. The reptile was green and when I disturbed it, it opened the mouth widely. The inside of the mouth was purple—almost black—and protruding was a yellowish-green tongue, held straight out, like a sting. Its defensive pose presented the air of something decidedly poisonous. I had come upon it suddenly and its intention was to give me a mental jolt. I was, in fact, so surprised that I failed to make a grab for it. It made a jab straight for my face and during the instant that I ducked it dropped to a lower brush and glided to cover.

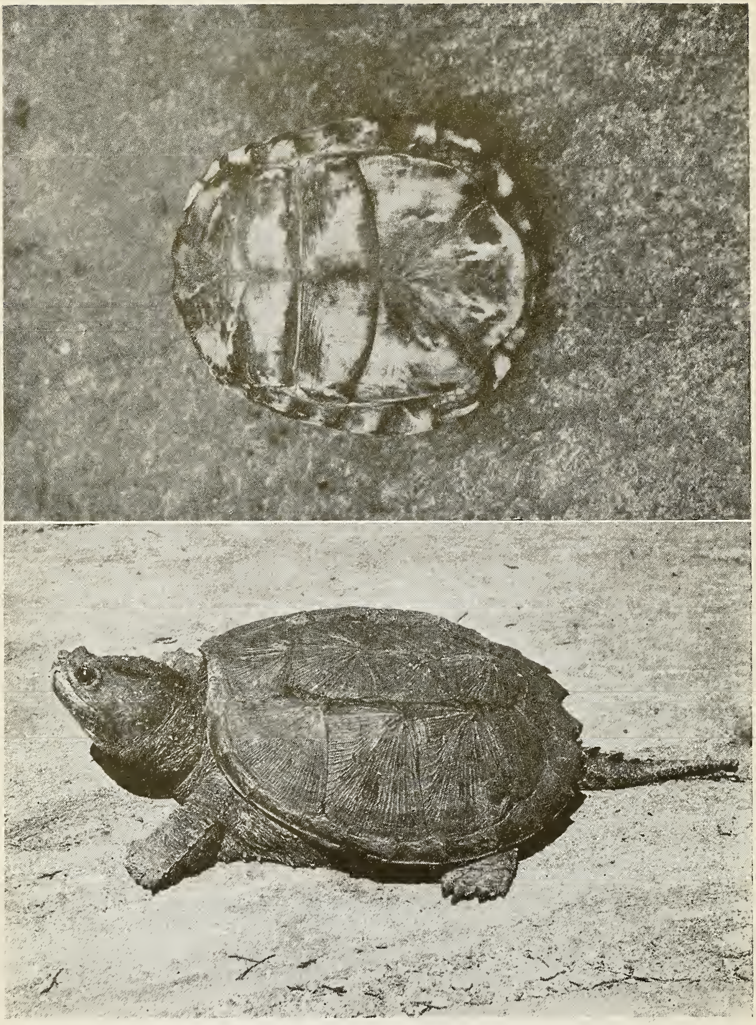
Are the natural enemies of harmless snakes fooled by such bluffings? I think so. There may be momentary hesitation brought about by instinctive thought of poisonous kinds. With its life endangered, a few seconds' delay may mean much to a snake in figuring its avenue of escape. The delay may be more prolonged, the enemy having no wish to be bitten, even figuring the opponent's teeth are not poisonous. Seconds count in warding off attack. That some of the predatory animals are bluffed by harmless snakes that put on airs was demonstrated by a weasel which I saw attack a yard-long milk-snake at the edge of a stone wall. The weasel rushed at the snake to bite it and the reptile threw itself into loops and struck at the sinuous mammal, which drew back. The snake rattled its tail among debris, reared into loops that made it look formidable. The mammal weaved from side to side in hesitation—which lost the fight. The snake went under a flat stone faster than pouring water downhill. Later, with a movie camera, I filmed another such combat—the snake escaping. There is logic to bluffing among harmless snakes or such specific and deliberate actions would not continue to be handed down through generations.

Protective coloration among snakes is not so evident as is to be seen among lizards. There are



Vine Snake. Protective resemblance crops out among snakes. This Brazilian species is pale green and difficult to see among tropical tangle.

Sand Viper. The Sahara provides this specialized reptile, which burrows in a moment so that only the top of head and eyes are showing. It thus avoids enemies and watches for prey.



Protection Among Turtles. The upper is a Box Turtle with plastron protectively closed. Other terrestrial kinds can close parts of the upper shell. Where shell covering is scant, powerful jaws are to be noted—as with the Snapping Turtle.

some where there is extreme adaptation along such lines. Such are the slender tree snakes of the New and Old World, mostly tropical; slender body, pointed head, gray or green coloration, so blend with branches and leaves that an observer a yard away might stare at a motionless reptile and not detect it. Also, these tree snakes have a way of weaving the head in the motion of a branch swayed by a breeze.

One defense differs from what is to be noted among ancestral stock, the lizards, and that is the presence of scent glands near the base of the tail. A slight exudate from these glands during the breeding season may furnish a trail for the meeting of sexes—the supersensitive tongue picking up the scent. There is a great difference, however, between the trace so exuding and an outpouring of secretion of which some snakes are capable if attacked. The effect may be sickening upon an enemy.

Some snakes lay eggs, others produce the young alive. The egg-laying and viviparous kinds are almost equally divided. Some of the egg-layers coil about the eggs with the intention of conserving moisture, which assists incubation. The eggs swell, and increase in size, if kept moist, which means strong snakelets to emerge from them. When litters are born to viviparous snakes, the infants go their way without parental attention. The babies of the poisonous kinds have perfectly developed fangs, in miniature, from the time the infants seek their first food. The killing of prey suitable to their size is carried on with the same actions as those of their parents.

There is no parental care among any kind. The story of snakes swallowing litters of young for protection is a legend—too good to die. Any snake that would stop to swallow a litter in time of danger would produce, by delay, the hazard of annihilation of parent and family. No such foolhardy risk would long endure as an instinctive inclination, nor do I believe that it has ever been evident. In years of observation, in the field and with captive snakes, I have never seen the remotest hint of it.

One thing about snakes that has always impressed me—that is in the temperate latitudes—is their sense of direction in finding specific hibernating quarters to escape the winter cold.

Under a temperature of 60° Fahrenheit they slow down, at 50 degrees they can barely find their way about, and at 40 they are inert. Few of their kinds can long survive that magic point of 32 degrees, when water freezes. Hence with the approach of autumn snakes that have been afield, all kinds of snakes, begin working their way back, in plenty of time, toward crevices into which they may go deeply to escape invasion of frost. These crevices are the hibernating dens which have been known to many generations of reptiles. They are not sought haphazardly; they are definite places to which numbers go year after year. I have seen crevices in ledges that have been worn smooth by the larger snakes, rattlers, blacksnakes and the like, that indicated centuries of populous colonies returning to the same spot—a particular crevice; one that led deep beneath the surface.

Near such places serpents lay their eggs or give birth to their broods of young. And in those young is born the sense to return to these places when the leaves begin to fall. Thus snakes which have been prowling woodland or meadow, possibly several miles from the hibernating shelters, return to such precise places every year before the chill of fall comes on. This urge and sense of direction, through tangles of brush or labyrinth of rocks, is to me as remarkable as the migration of birds.

Hibernating quarters vary according to the size of the clan. An ancient tree may have hollows at its roots which lead deep downward; a bank of shale at the edge of a brook may have successive hollow strata; beds of sphagnum moss in open places may be compact enough to generate protective temperature; and all such spots are definitely known.

Burly as they are, the crocodilians—alligators, caimans and crocodiles—are not destined to long endure in this changing world. They are survivors of a dim past, sprawling mud-bank, sand-bank denizens, too apparent in their bulk to survive the encroachment of man upon their domains. Their forms fit into scenes preceding the Pleistocene. Except in the dank river swamps where heat and disease hold humans in check, they will disappear while other legions of better adapted, more secretive wild life will continue in numbers.

Turtles and tortoises are examples of radical tryouts among vertebrates along protective lines. The skeleton has become fused into a walking fortress, sheathed with horny plates. Here and there among them are mechanical improvements—hinged sections to draw the upper shell down tightly or raise and close the lower shell. Others have armored limbs which can be jammed together to protect the shell opening. Among those where the openings for head and limbs is wide, powerful cutting jaws may be darted in defense, thus providing a weapon to guard the breach.

There are variations in shells, such as flaring or protecting eaves, under which turtles with particularly long necks may tuck these members sideways. A novel form of shell has developed with a small African tortoise—a land species—which shelters among shelving rocks. The top of the shell is pliable, leathery and may be expanded with air. When disturbed in shelving crevices these creatures expand the shell and become so tightly jammed that no enemy can extract them.

Turtles and tortoises show the most extreme care among reptiles in hiding their eggs. The eggs are buried and require a longer time to develop than with most cold-blooded creatures. After scooping a deep hole and in it depositing the eggs, the female toils for hours in filling and tamping the hollow, thence smoothing the surface to resemble surrounding ground. The young dig their way out a couple of months later—sometimes not until the following spring, with water turtles. They receive no parental care.

The provision of a fused, skeletal fortress, novel as it is, does not seem to have been a marked success. It is cumbersome and has slowed the owner down. Numerous world-wide races of such reptiles passed out of existence in prehistoric times. Of the more than five thousand kinds of modern reptiles, the shell-encased turtles and tortoises of today number but slightly over two hundred known species.

CHAPTER VII

POISONOUS SNAKES AND THEIR ENEMIES

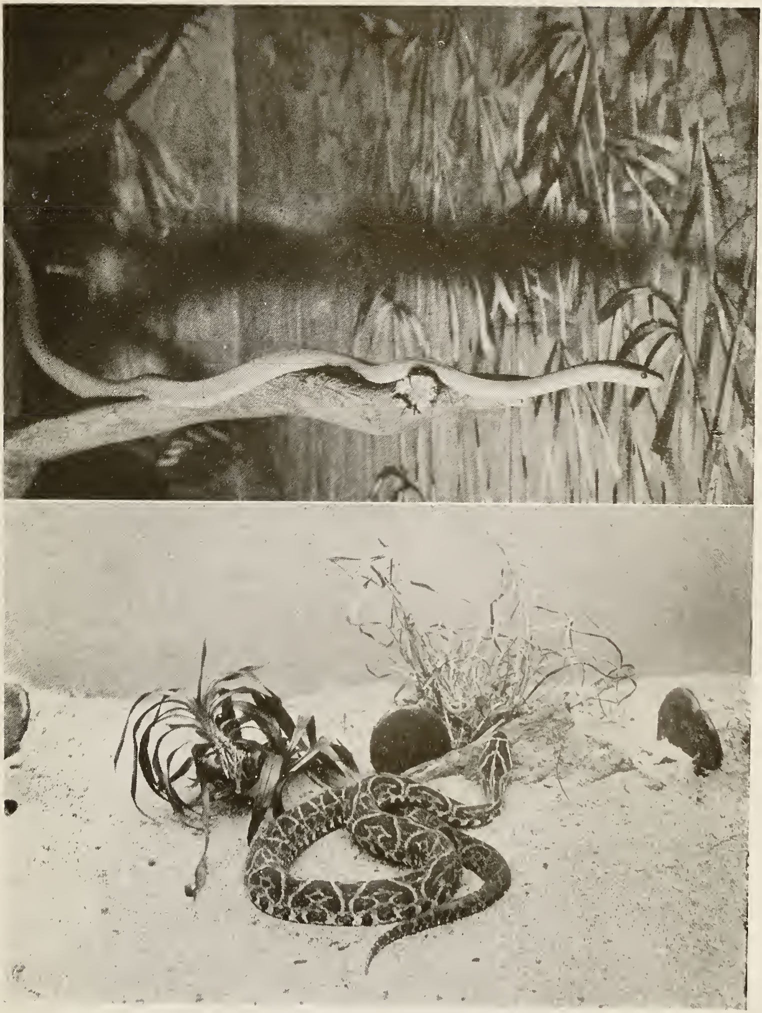
SEARCH as one may among the higher or backboned creatures, on land or in the sea, and no greater perfection in weapons designed to kill can be found than in the fangs of poisonous snakes.

No weapons similar to these injecting teeth, connected with sacs of lethal fluid, exist among other vertebrates. Poison-injected wounds may be made in lightning-like fashion, wounds that may be deadly to man in a few hours; overwhelming to small animals in a few seconds. Thus not only are there deadly weapons, but the marvelous adroitness in their use is unique. In the face of this it would seem as if the larger kinds of venomous serpents, of which there are many, would be safe from enemy attack; that they might, figuratively, go about with a chip on the shoulder. But this is not the case. Enemies have learned how to attack them; to feed upon them. They have enemies among mammals, birds and reptiles. Some of these are immune to reptile poisons.

Thus the average poisonous snake is as sly and watchful as other kinds that have passed in review in this story. In the preceding chapter it was shown that some harmless serpents "mimic" the poisonous snakes; make themselves look as dangerous as possible. They may envy their poisonous neighbors the possession of fangs; in fact, count too much upon putting up a show. Bravado is not the rule with the fang possessors. Few of them put on airs.

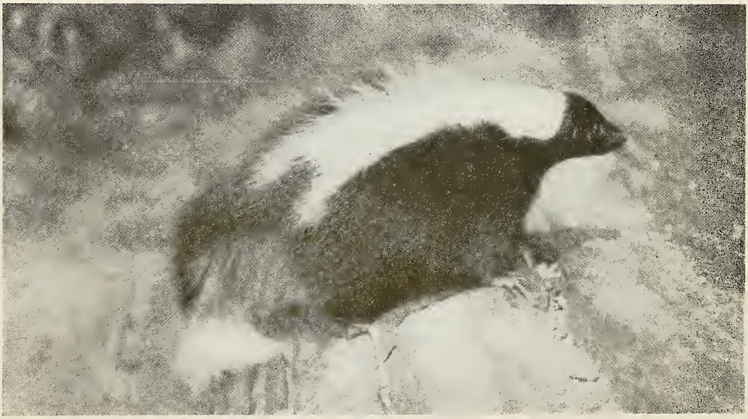
The evolution of serpent fangs goes well back into geologic time, at least into the Miocene, as remote as eighteen to twenty million years. The strata of Miocene rocks have yielded vestiges of poisonous snakes not unlike members of families that exist today.

Three types of fangs developed among the early snakes. The crudest were at the rear of the upper jaw. These teeth were short, rigidly attached and had a groove on the front surface. This fang structure has continued to modern times with little or no improvement. Its object was to grip and hold



Types of Deadliness. African Mamba (*upper*) and Brazilian Urutu (*lower*). With the former the fangs are minute and a droplet of nerve-attacking poison is deadly to the larger animals. The Urutu deeply injects blood-destroying poison with its long fangs.

African Meerkat. One of the reptile eaters. Snakes and lizards have many enemies among such small kinds.



Eastern Skunk. Such small animals are enemies of the reptile clan and have developed chemical warfare as a defense.

prey of small or moderate size, while a paralyzing poison subdued the quarry. We call the large number of such serpents now inhabiting the world, the rear-fanged snakes. They are of small to moderate length and their crude fangs render them but little better off than harmless snakes, as with most of them their venom has little effect except upon lizards and birds.

Another fang development, which became far more formidable, started with a pair of short, stout teeth which were grooved and rigidly set in the *forward* part of the upper jaw. The glands containing poison and connected with these fangs, instead of being a small sac in the upper lip area as with the rear-fanged kinds, were situated in the temples and of size to contain a considerable amount of poison. Each extended forward as a tube to the fang and was encased by the masseter, or biting muscle, and when this was contracted the gland was compressed. Such were the early elapids, the ancestors of the cobras, mambas and coral-snakes. Their fangs grew longer and stouter, but even with the modern kinds, some of which are the deadliest of the world's snakes, they are relatively of much shorter length than the fangs of viperine snakes. Among the modern elapids there has been a tendency for the groove to fold around the fang and the end to open like a hypodermic needle. Thus with most of them the fang contains a canal, more or less imperfectly closed. In using such fangs the elapids bite and hold on.

It is with the viperine serpents—such as rattlesnakes, the moccasin, fer-de-lance, bushmaster, typical Old World vipers and the fairly numerous kin of such species—that poison fangs have attained the greatest perfection. With such the venom-injecting teeth are much longer. They are hollow, with an elongate opening at their tip. That the ancestors of such reptiles had grooved fangs is indicated by a faint line down the face of the fang. Perfection was reached by the tooth completely circling the groove in a way to leave an inner canal. This fang structure has been duplicated by human science in producing the hypodermic needle.

With the lengthening of the fangs of vipers, the bones to which they were attached became movable, and necessarily, for fang growth went on to such an extent that the long weapons folded back against the roof of the mouth when the jaws were closed. As such serpents strike, the jaws are opened to an almost up-and-down extent, and the fangs swing outward until their points are directed forward. The head is darted from a lateral loop of the neck. When the fangs reach their mark there is a stab inflicted from the force of the stroke, simultaneously aided by a biting action, this accompanied by the large poison glands in the temples being squeezed by contraction of the biting muscles. Stroke, bite, pressure on the poison glands, injection of the venom and return of the head to the snake's defensive position normally takes less than half a second.

Such are the defenses of poisonous snakes, with weapons primarily designed to subdue their prey. The high toxicity of their venoms is too well known to warrant description. It is sufficient to say that a single drop of the poison of many species can kill a man within a few hours and that the shock of that much poison injected into the flesh of a small animal is almost immediately overpowering. It is a case of body bulk against the amount injected. I have seen small animals killed almost instantly. Even though the victim is large, the bite of a poisonous snake produces an instantaneous condition of confusion or terror. Instinctive fear of reptile poisoning is a part of this; a stroke, a sharp pain and crashing shock of mind in the realization of what has happened. Here is the explanation of harmless snakes putting on their simulating airs—to inspire fear among possible enemies.

I have drawn a fearsome picture of poisonous snakes, but they warrant it. There are many wild creatures as much afraid of them as man, hence a listing of enemies that deliberately attack them is of importance. It has been noted that the poison-injecting fangs are not solely weapons for defense as are the weapons of some animals. *Primarily,* the fangs quickly subdue the reptile's prey, and the snake's stomach is not affected by the poisoned victim. *Secondarily,* the fangs are used for defense, and the reptile well realizes the power of its specialized teeth, the probability of a bitten enemy recoiling, hence the gaining of time for escape, or if there is no avenue of retreat the standing off of an intruder suddenly stricken with the poison.

In warmer parts of the world the most numerous enemies of poisonous snakes are small mammals. Among Old World kinds may be listed the numerous species of the mongoose group. These are the viverrines—belonging to the family *Viverridæ.* In both the New and the Old World other enemies are members of the *Mustelidæ* (mustelines), principally skunks, of large and small species. The animals of both families are carnivores—active, sharp-toothed predators. Other mammal enemies are the hedgehogs (Old World). They belong to the grouping of the insectivores—the stronger kinds of which are partly flesh-eaters.

The standing of the mongoose, allegedly sworn enemy of the cobra, needs explanation to clear up the too common ideas about it, which may be largely wrong. Kipling has set it on a pedestal in his "Jungle Tales," the familiar Rikki-Tikki, exploited for its dueling with India's hooded snake. The common and incorrect idea is that there is but one mongoose, *the* enemy of the cobra. Actually, there are a dozen kinds of mongoose (or mongooses, if an awkward plural is used) in India and Malaysia and another dozen kinds in Africa.

All are exceptionally quick, sinuously moving animals, feeding upon small birds and their eggs, rodents, lizards and snakes. Their prowlings are not guided particularly in a search for snakes, but such reptiles, both venomous and harmless, are a part of their prey and are attacked with skill, courage and agility, which shows that generations of the mongoose tribe have adapted themselves to the tackling of quarry that may put up a dangerous fight.

As all of the mongoose species fight alike when attacking a poisonous serpent I will outline a battle and analyze the fight in "rounds" as I have seen it. The principals will be an Indian cobra and the Indian gray mongoose (the Rikki-Tikki of Kipling). The battle would be the same with cobras of Malaysia and such mammals as the spotted Burmese mongoose, the ruddy mongoose, the Ceylonese mongoose, the striped-necked mongoose, the Javan mongoose, the short-tailed mongoose, other mongoose of the Orient or mongooses of Africa battling with the dozen kinds of cobras of Africa—the real headquarters of the cobra genus.

When mongoose meets cobra the former is invariably the aggressor. I have never seen indication on the part of the snake to rush in and seek to slay its enemy. The reptile's attitude is that of cautious defense. The cobra rises in combat pose and by its dilatable set of neck-ribs, spreads its hood. This, according to the cobra's idea, is a fearsome pose. Reared like a high, decorative candlestick, the snake watches, its head turning to follow every move of the enemy. What its inclinations may be, handed down through generations of such duels, is hard to surmise. Nine out of ten cobras entering upon such duels are doomed. Fearsome though that rearing pose may appear to other creatures, the mongoose takes advantage of it. It would be better technique for the cobra to double up its neck and strike. Reared as it is, its biting motion is limited to a forward sweep, a sort of bow. This is far slower than a strike, and the mongoose knows it.

The first round consists of the mongoose stalking around the snake—insolently nosing closer until its snout may touch the loose coils that support the reared anterior. This nosing is from the sides, the mongoose darting here and there, the flattened neck of the reptile unable to be shifted quickly enough to deliver an accurate sweep. Nevertheless the cobra turns, strikes and misses—badly. Thus closes what might be called the first round of the fight. No points are scored by either unless it is conceded that the mammal has so enraged its opponent that the latter is inclined to strike wildly and is a bit winded.

Round two may be defined in showing bolder actions on the mammal's part. The mongoose circles and rushes in as before, but this time with nips of its long and sharp canine teeth. The snake strikes furiously, but its opponent ducks quicker than the turns and sweeps. To tantalize the cobra the mongoose may face it, edge forward to coax a blow, then duck to avoid it—by inches. This phase of the fight closes with the snake winded and its sweeps more wildly aimed. Honors go to the mongoose for dexterity.

Round three is short. The mongoose circles and nips the cobra on the tail. The bite is as quick as a flash and the mammal darts back and crouches. As the cobra turns, the mongoose leaps for its neck, right behind the head, the long canines chewing and crunching to sever the spinal-cord. This may be done in a few seconds or the two may thrash and roll, the serpent seeking to grip its adversary in a coil; a rarely effective action, as the cobra is not a constricting type. The courageous mammal usually breaks the neck of its victim and later devours a portion of him.

While the terms of pugilism in defining the parts of the combat may seem a bit stretched, I have taken liberties in emphasizing three definite tactics of the mongoose in fighting a deadly snake. The entire performance may not last more than a minute, or it may last as long as five minutes, but the mammal's technique follows the actions outlined.

There have been allegations that the mongoose is immune to the poisoned bite of a cobra, and that if bitten it rushes off to eat some plant that will neutralize the venom. I am convinced that neither is the case. The mammal may have some resistance to snake poison, varying resistance having been noted with the snake-killers, but I think that a well-delivered cobra bite would kill a mongoose.

If a cobra does get hold, it chews, keeping its fangs imbedded and injecting much poison. I have heard of specimens of the mongoose being bitten and dying.

Skunks are snake-killers and study has shown some to have high immunity against serpent poison. This comes from their habitat being in regions where the quick-striking viperine snakes are common. There is far more probability of a mammal being hit in a fight with a snake that doubles its neck and lunges than in side-stepping the sweep of a cobra. I had demonstrations of this in Brazil, the principal being a large and handsome snake-killing skunk. This animal lives in good hunting-ground, as there are many species of the fer-de-lance clan. The poisons of such snakes are dramatically terrible in their effects on non-immune animals. They destroy blood and dissolve tissue, differing from the venom of cobras, which attacks nerve centers.

I was thrilled to see how the South American snake-killing skunk tackled reptiles of the fer-de-lance kinds. There was but one part of its technique that resembled the battling of the mongoose.

The fight I saw was staged in one of the arenas of the serpentarium at the suburb of Butantan, near São Paulo, Brazil. The snake was a five-foot jararaca, freshly caught and full of vigor. It was stretched on a grassy knoll when the skunk was put in the enclosure. The mammal wandered around before it saw the snake, then trotted straight at it. The jararaca threw itself into a coil, vibrated its tail and with looped neck waited to strike the approaching mammal.

There was no hesitation on the skunk's part. It walked right into the reptile's striking range, took a stab on the nose from the fangs, shook off drops of blood, pounced on the jararaca's back and seized it a foot behind the head. The viper retaliated by turning and embedding its fangs on the mammal's upper jaw. It held on, the fangs advanced in chewing bites. This would have been ghastly injury to a human—with so much poison injected. But the skunk was the master. The reptile's spine was pierced. Overcome, it loosed its hold and writhed like a thing gone mad. The skunk bit it in other parts and the struggles ceased.

I remarked to Dr. Vital Brazil that the skunk was utterly careless and made no attempt to escape being struck.

"That is their way. They attack without fear or caution," said the eminent doctor. "The species has perfect immunity against the poison of these vipers and appears insensible to pain from the fang stabs."

I learned that the Brazilian government protects this species of skunk and there are related kinds being studied, as their habits are thought to be similar.

With such mammalian enemies, and others, equally formidable, there may be explanation for the large litters of young of the fer-de-lance allies (the genus *Bothrops*). Among three litters of fer-de-lance, I counted respectively 64, 65 and 71 young. These snakes are born alive, provided with fangs and ready to shift for themselves. Particularly large litters of young or excess numbers of eggs laid by other forms of life indicate a tendency to perpetuate a species against enemies. That skunks in North America are inclined to attack poisonous snakes and have resistance to poisons, seems probable from experiments I have made, but they are not so persistently or bravely snake-killers as the tropical American kind.

A number of birds are snake-killers, species with respective methods of technique in killing poisonous reptiles.

Birds of prey vary their diet by swooping down on a coiled reptile, grasping it with piercing talons, soaring over a rocky ledge, dropping the prey and repeating the maneuver until a battered carcass is ready to be torn into dietary shreds.

The "road-runners" of the southwestern United States circle a snake like the mongoose, rushing in to batter it with strong beak. Rattlesnakes are worsted in such attacks.

The South African secretary-bird has a technique all its own. It receives its name from several long feathers at the rear of the head, in position like a quill stuck behind an ear. In form this bird is like a stork and is thought to be a stork-like member of the carnivorous birds of prey. Suspended on long shanks the body is well up out of the way of a serpent's stroke. The secretary-bird stalks up to a serpent, not hesitating to approach the most poisonous kinds, and drawing up a strong and calloused foot takes deliberate aim. There is a downward blow, so swiftly delivered that it produces a thump. The bird recoils from retaliation as if its legs were on springs. A few such blows will batter out the life of a cobra or puff-adder.

But not alone are mammals and birds specialized enemies of poisonous snakes. Right among the serpent races are killers specialized to attack, quickly subdue and devour fanged kinds of the most deadly types. These are constrictors which wrap a poisonous victim in their coils and squeeze it to death. They are resistant to poisons; and while they seek to evade wounds from long fangs by seizing a victim by the neck and quickly entangling it, they are often wounded by fangs that would quickly poison ordinary reptiles, yet they are not affected by the injected venoms. Such are the king snakes of North America and similar serpents of Europe, Asia and Africa.

One of the most spectacular is the mussurana of tropical America. It attacks and devours the most devilish species of the New World vipers, killing and swallowing reptiles two-thirds its length. It is a black and lustrous, whip-like creature growing to a length of six feet. Curiously enough, it is exceptionally gentle with man. I have handled a number of mussuranas yet have never seen one make an attempt to bite. This is one of the snake-killers that seems to confine its diet altogether to snakes.

Hence with strong enemy background the average fanged serpent, instead of being a wanderer insolent in knowledge of stabbing weapons to inject lethal fluids, is as cautious and side-stepping as other forms of life. Even protective coloration has cropped up among these creatures, and habits of remaining motionless to escape detection by intruders. In the open they fight with an air of doing devastating harm, while a few, like the king cobra and mamba, are bold enough to attack even man during the reptilian breeding season. Summarizing their habits, however, we must acknowledge that all of these formidably armed vertebrates seek no more than a right to live among the other legions of the earth.

CHAPTER VIII

THE STRUGGLE OF THE AMPHIBIANS

REMNANTS of primitive amphibian races are scattered all over the temperate and tropical parts of the world. They are miniatures from ancestral stock and may be likened to sparks glowing in the bed of a dying fire.

Amphibians remain as a sort of living reminder of an age when life started to emerge from the waters upon an earth that was cooling. They represent the linking forms between fishes and reptiles and retain a mixed-up water and land existence. They begin life dependent upon water and most of them transform to air-breathers. Even when becoming terrestrial they are dependent upon moisture, owing to soft, scaleless skins. Those that transform but remain aquatic have skins of such absorbent nature that lungs have deteriorated or disappeared, the body absorbing oxygen and purifying the blood without breathing. Such are the water salamanders or aquatic frogs that prowl in deep and cold waters.

Making up the amphibians are about a thousand and five hundred kinds of frogs and toads, and a hundred and fifty tailed kinds, the newts and salamanders. Also there are about seventy-five species that have degenerated to mostly blind forms that are limbless and range in size from earthworms to small eels. The latter are the tropical cœcilians.

Largest of the modern amphibians is the giant salamander of Japan, attaining a length of four feet. It is far in excess in size over other salamanders, though inferior to amphibians of prehistoric times. Of frogs and toads the giant member is *Rana goliath* living in the Cameroons of Africa. Fully grown it weighs more than five pounds and can swallow a rat. Of the smallest amphibians there are salamanders two inches long and frogs so small that a pair could sit side by side on a dime.

While more primitive than reptiles and in much less variety of form, the remnants of amphibian races that remain upon the earth show far more varied and particular care of eggs and young. In another point, they differ from reptiles of which they stand as ancestral stock. With frogs and toads there are voices. These are mating calls, possessed by the males. Such gift, for the gathering of the clans in breeding times, means much to the continuance of races. The calls of frogs and toads are a harbinger of spring in the temperate zones. In tropical latitudes, when the rains set in the night air reverberates with bell-like notes, chatters, squawks, moans, grunts and sounds outside the describable. The clans then gather near water to lay eggs, to hatch into fish-like young under various provisions for the progeny to start life. Fluid medium for the brood is essential. But it is not always upon the ground that it is sought; it may be overhead in froth reservoirs, in rain-filled bowls, in cupped parasitic leaves, even in water-saturated, cell-indented backs of the parents themselves.

Surrounding small creatures with soft, naked skins are the inevitable dangers from predators, particularly seeking the amphibians owing to weakness of the greater number, the fragile nature of their eggs, and the delectable immature or tadpole stages. Such forms attract the smaller carnivorous mammals, birds, lizards, snakes, fishes, even the larvæ of the larger aquatic insects. The most persistently dangerous enemies of mature amphibians are birds and snakes. The greatest danger to the delicate young comes from the attacks of fishes. Among these weaponless forms many ways and devices to exist have come into being. Without unique habits to prolong their kinds, the weak races of modern amphibians would soon be swept away.

Frogs and toads have very ancient ancestry. Fossil traces are found in rocks geologically far older than those yielding forms that look in any way like modern reptiles. In prolonged development several things have happened. Some frogs and toads remained content to lurk in marginal vegetation near water, others sought a strictly aquatic life, never leaving the water and swimming with huge webbed feet. A few of the big aquatic kinds crawled slowly about at considerable depth, like sluggish crabs. Some took to digging burrows and others groveled in soil like moles. Many grew suction disks on fingers and toes and took to the trees.

The so-called tree frogs and tree toads sprang from different and unrelated groups. These arboreal amphibians look alike, each toe and finger expanded as an adhesive pad, but they merely show the tendency of members of separate groups to get off the ground. In Malaysia is the extreme of frog life in trees, a type with greatly elongated fingers and toes carrying not only the suction disks but frills of skin enabling foot and hand to be opened like fans and guiding the owner in scaling flight from tree to tree. Thus has a "flying" frog come into being.

Many frogs and toads are among the masqueraders to be listed under "mimicry." There are kinds that blend with marginal reeds, that match the soil, the browns of forest debris, arboreal kinds that are like patches of lichen, or leaf-green with camouflage markings to break their outlines.

The most pronounced example of protective resemblance and actions to take advantage of it I have seen among amphibians, came to my attention with a large tree frog of Brazil. It crawled like a sloth, every motion slow and studied, and I ultimately found that it never jumped, but could walk up walls and across horizontal surfaces like slow-motion in the movies. It was leaf-green, with dull luster like a leaf. Its eyes were blood-red. Its most surprising aspect was in resting on a heavy leaf. It flattened and its limbs were drawn inward and indented to the body. The head was pressed downward and the eyes tightly closed, their spherical outlines sinking into the skull sockets. The posture was strange enough, but a purplish marking around the lower margin of the body brought out the significance of evasive defense. In-tucked toes and fingers were purple, as was the lower half of the limbs, and this in combination with the purplish stain along the lower body broke up the outline of a frog. From a few feet away, the effect was of a leaf, resting upon another; the purple, the shadow of the upper leaf.

Poisonous skin secretions, of different degrees of toxicity, afford protection against being eaten by some predators, although some enemies of amphibians have immunity against these venoms. I recently saw an example, under natural conditions, of such protection.

Walking along a marsh I heard the scraping rustle of a snake in rapid motion. A glance in the direction of the sound showed a large striped snake pursuing a frog over dead reeds. The frog was making good progress and might have escaped if it had not tried to burrow into the reeds. The snake was on it, seized it by a leg and started to move its jaws in the forward-and-backward motions which draw prey into the elastic mouth. But the grasp was retained only a few seconds. The reptile suddenly threw its jaws apart as if it were yawning. The released frog bounded off. I had noted what kind it was in the brief time the serpent held it—the spotted or "pickerel" frog. It is the only species, of the five kinds of local frogs, with toxic skin secretion.

The snake was in such distress it made no attempt to escape as I went close to it. Its ordinarily pinkish mouth became very red. There was excessive salivation and it gaped and moved its head from side to side in distress.

In localities similar to the occurrence of this episode there is another spotted frog—the leopard frog—which has no toxic defense, but evades pursuers by leaps of such speed that it looks like a bird skimming the grass. Of the other local kinds, the very aquatic bullfrog and the pond frog are highly sensitive to danger, leap into the water, kick up a cloud of silt and, hidden by the smother, dig in to cover their backs. The remaining local kind, the wood frog, living amidst debris of forest floors, is protectively colored to a remarkable degree. Thus are measures of protection among the common local frogs, by skin secretion, mimicry or particularly evasive habits.

I have wandered, however, from the point of poisonous skin secretions. The common toad—in fact, all typical toads, of which there are many,—has little glands scattered over the skin and a pair of large glands at the rear of the head. These contain a creamy poison, highly irritating to mucous surface, and introduced into the stomach may produce symptoms severe enough to cause the death of small animals—even creatures the bulk of a fair-sized dog. The latter type of animal may be unwise enough to seize or play with a toad, and contact of granular skin with the mouth parts produces immediate salivation with continuity of distressing symptoms. A canine victim of such accident may champ its jaws and run blindly to allay its suffering. I have seen dogs dig out toads and seize them, and their subsequent excitement would have been terrifying to anyone not acquainted with the circumstances. The thought might have been that the dogs were in the throes of rabies.

Action of such poison has been experienced by me in the laboratory, in experiments with the marine toad, widely common in the American tropics. The poison is collected by squeezing the big glands behind the head. It spurts in viscid white streams from coarse pores. The technique in collecting it is to have it ejected against a piece of glass. Usually the glands may be so compressed that ejection may be guided toward the glass. In doing this, with a very squirmy toad, a droplet flew up and struck the corner of my eye. It was but a minute or so to get to the water-tap, but the delay was long enough for absorption of the poison. There was intense pain, the eye turned very red, with temporary dimming of sight, and when the pain had subsided, after several hours, the eyelid was numb and it was difficult to blink.

In taking motion pictures of another kind of toad, it was necessary to handle the creature a great deal. And during the focusing of the camera and adjustment of the lights, thought of toad poison was forgotten and I happened to moisten a finger on my lips. In this instance there was no pain, but within half an hour one side of my mouth and a portion of my tongue were as numb as if I had had a tooth extracted with injection of novocaine.

Thus many amphibians are safe from attacks of small mammals with instinctive caution of frog and toad poisons. Some snakes eat toads and the poisons of skin glands have no effect upon them. Some snakes, in fact, prefer toads to other foods, and a few confine their diet to toads. The defense of toads against such immune enemies is to greatly distend the body with air and produce bulk beyond the capacity of the swallower's jaws. This has been checkmated by some toad-eating snakes by fang-like teeth in the rear of the upper jaw. Such teeth puncture the toad and thus expel the air. However, there are frog-eating snakes that will not eat toads. No snakes with which I have had experience will eat frogs with poisonous skin.

There is a marked line of definition, or character of poison, between that in the glands of toads and the slimy, toxic exudate from the smooth skin of frogs. In experimental work I had no difficulty in getting a common Brazilian watersnake to gobble down a small frog of the kind that figured in the garter-snake episode, previously described. Such tropical snakes are voracious feeders and bolt their food so quickly I thought I could fool this reptile and note what might happen. The motion of the snake's jaws was so quick in engulfing the little frog that the reptile didn't notice the irritating skin; but within half an hour the snake was dead.

Skin poisons among tropical frogs run to far higher toxicity than with the northern species. There is a big tree frog in Haiti and San Domingo with such irritating skin that one's hands are burned as if by acid if a specimen is held but a few minutes. This is unusual among such exudations, as there is usually no effect in the handling of amphibians unless there is a cut or bruise or the poisonous secretion comes in contact with mucous membranes. With a genus of tiny frogs (*Dendrobates*) of South America, the members may be handled, if the skin is intact, without bad effect, but their skin poisons are so deadly they are used by the Indians to poison the darts of their blowguns.

While poisonous creatures as a rule are not "dressed up" to indicate their nature, "warning coloration" is not uncommon among frogs and toads having venomous skins. This may be in patches of vivid red, yellow or green standing out on a black background. A number of the poisonous frogs have the inner and under parts of the hind legs of contrasting colors to other parts of the body.

There are other protective measures among frogs and toads. With some burrowing kinds the top of the head is very hard. They dig tubular shelters and back in, then bend the head forward at almost a right angle so that it blocks the hole like a deeply driven cork. There are species with similar habits living in holes in trees. There are Asiatic and African frogs having the bone of the thumb piercing the skin as a powerful spur. The forelimbs are very strong and these frogs are known to have grasped the fingers of unwary collectors and made painful wounds. They have earned the name of dagger frogs.

The most curious defense I have seen among frogs is that of biting. This might seem to be the very last resort of a frog, but the big species of *Ceratophrys,* or horned frogs, of South America, can inflict painful bites. I well remember my astonishment, on a visit to the London Zoo, to hear the keeper of the reptiles tell about being bitten by a frog. As evidence he showed a finger bound up in a bandage. Seeing my look of doubt he led me to a glass case containing a huge horned frog as broad as it was long. Its back was a decorative pattern of green and purplish brown; its mouth a grim line, a full third of the anterior part of the strange animal. As it was touched with a stick it uttered a cry between a squeal and a bark and jumped at the stick. I was assured it could bite with the strength of a turtle, and hang on. It was my first inspection of a living specimen of *Ceratophrys.* Since then I have had several, with lateral diameter of body the size of a small plate. All of them barked and tried to bite.

The eggs of amphibians are jelly-like, of high aqueous content, fragile, and attractive as diet to many small forms of life, vertebrate and invertebrate, hence it is natural that many phases of protection should have come into being. With a small European toad the eggs, to a moderate number, are laid in a glutinous string which the male winds around his hind legs, then retreats to a damp cavity, emerging on dewy nights to bathe them in wet grass. When the tadpoles are ready to hatch the attentive father enters a pool and liberates them to carry on their transformation of growing legs, absorbing the tail and becoming terrestrial toadlets. With the female of an Australian tree frog, the eggs are carried on her back, kept in place by a rimmed enclosure of skin which develops during the breeding season.

There is a long trail of similar habits, but the ultimate in parent-carrying habits is with the large, strictly aquatic Surinam toad, of which the male presses several hundred eggs into cavities of the female's back. Each cavity grows a cap-like cover and under each little flap an egg hatches, a minute tadpole undergoes transformation in miniature to the parent form and the infant toads pop out ready to begin life of their own accord.

With most of the tropical tree frogs but a moderate number of eggs are laid, with some not much more than a dozen; but note the care of deposit of such eggs—the greater precaution the smaller the number of eggs among the amphibians. With several South American species the male and female ascend to branches overhanging water. Both proceed to hold the edges of a leaf together with their hind legs. A bowl is formed and in this the eggs are laid, a gelatinous substance being deposited which cements the leaf in the form of a funnel. The eggs absorb the tropical moisture to the extent of becoming globules of water. In these the tadpoles remain until nearly ready to transform to frogs; and when they burst their encasement and drop to the water they are protected by being almost as transparent as glass.

Another tropical American tree frog selects a knot-hole in a tree, lines it with beeswax to make it watertight, and within this smooth chamber lays its eggs in a mass of aqueous froth in which the tadpoles hatch and undergo transformation. Nest-lining material is always abundant owing to the presence of stingless bees which swarm throughout the tropics.

Nests of absorbent froth are made by unrelated kinds. With some the froth is beaten by the fore-legs until it forms a large mass; others confine the beating to the hind feet. An African species beats up its foaming nest in quite open places and the outside portion hardens into a protective shell during development of the young.

Of frogs and toads which lay their eggs directly in the water with growth of the tadpole prolonged, there are divergent actions among species to seek safety for the eggs; or under conditions where the parent is careless there is an enormous number of eggs, a small percentage of which get through, about equaling the results of the careful egg-layers. Two extreme examples show this. One is *Leptodactylus,* a large frog of South America, and the other, the common toad (in fact, all northern toads).

Leptodactylus heaps up a mud corral near the water's edge and in this lays a moderate number of eggs. The tadpoles hatch, and gain strength and activity to evade enemies in deep water, when the seasonal rains come on. These wash away the sheltering mud wall and liberate the tadpoles in pond or stream. But how different are the habits of the common toad! The eggs are commonly laid in rain pools, where there is hazard of seepage or evaporation. Such may happen in a number of pools except one or two in a fair-sized area, which means that masses of eggs are dried up and thus destroyed. One or two remaining pools are thus the source of toad continuance.

In automatic balance to such parental carelessness the toad is provided to lay eggs not in hundreds, but in thousands. From five to eight thousand have been counted in the egg mass of a single toad. Even at that, there is guard against pool evaporation in the speedy transformation of toad tadpoles. They start to grow legs when the tadpole is less than an inch long and quickly absorb the tail, but minute toadlets go hopping off through grass jungles teeming with dangers; even the larger ants attack them. It is estimated that less than one per cent of the toad progeny reach maturity.

With ordinary frogs, where eggs are laid in permanent bodies of water, hence there is no danger of evaporation, the number on the average is about a third that of toads. But even two to three thousand eggs of a frog may seem a large number until it is deduced there is no provision for protection of the tadpoles just after hatching and until they gain strength and activity. The freshly hatched frog tadpole is quite helpless, has poor sight and spends several days clinging to stems of aquatic plants by a suctorial disk. At such a stage it is easy prey for the larvæ of aquatic insects and predaceous fish. There again is provision for continuance of races in production of excess numbers. Thus does egg-laying vary among amphibians.

Continuance of care, after hatching of the young, is here and there to be found with the tailless amphibians, but not so commonly as safety for the eggs to be seen among tropical kinds. Many of the arboreal frogs and toads lay their eggs directly in water, in variance to the nesting of eggs already described. Among the former an unusual habit is to be noted with the males of the tropical American genus *Dendrobates,* which stand by the pools in which eggs have been laid and in unfavorable conditions or evidence of evaporation hop in and collect the tadpoles, which attach to the father's back by suction. Thence the male hops off to find a better nursery pool. The back-carrying habit of the Surinam toad, with young developing in skin craters of the female, has already been noted.

A unique phase of tadpole care is carried on by a West African frog. Here again, as with *Dendrobates,* the male takes up the burden. His throat has a dilatable "singing" pouch and in this he pockets the eggs. After they hatch he continues to thus carry the family until the pouch is so extended that it bulges sideways and becomes almost as big as his body.

Salamanders and newts are *tailed* amphibians, lizard-like in form, but differing from reptiles by their naked, scaleless skin. Like frogs and toads their life is dependent upon dampness. Some live under logs and stones; others are aquatic. They are weak reminders of large forms of ancient amphibian life. As with tailless amphibians, they begin life as tadpoles, but unlike those of frogs and toads, their forelimbs are first to appear; also the greater number have feathery gills which are absorbed during transformation. They seek minute living prey while the tadpoles of the tailless forms have rasping mouths and are herbivorous.

The egg-laying habits of salamanders are not so varied or ingenious as those of frogs and toads, while the adults as a rule are slow-moving. Thus handicapped, in deterioration of their races their numbers are far inferior to the tailless members of the Class Amphibia. Their most impressive kind is the giant salamander of Japan, flat-bodied and growing to be four feet long. It never leaves the water, but comes to the surface for gulps of air. Its wide mouth and distensible throat may be so quickly opened that inrush of water carries small fish into the mouth with such speed they are literally shot to destruction. Specimens have been known to live over fifty years in captivity. This strong and ugly creature hints of past races whence the modern amphibians have evolved.

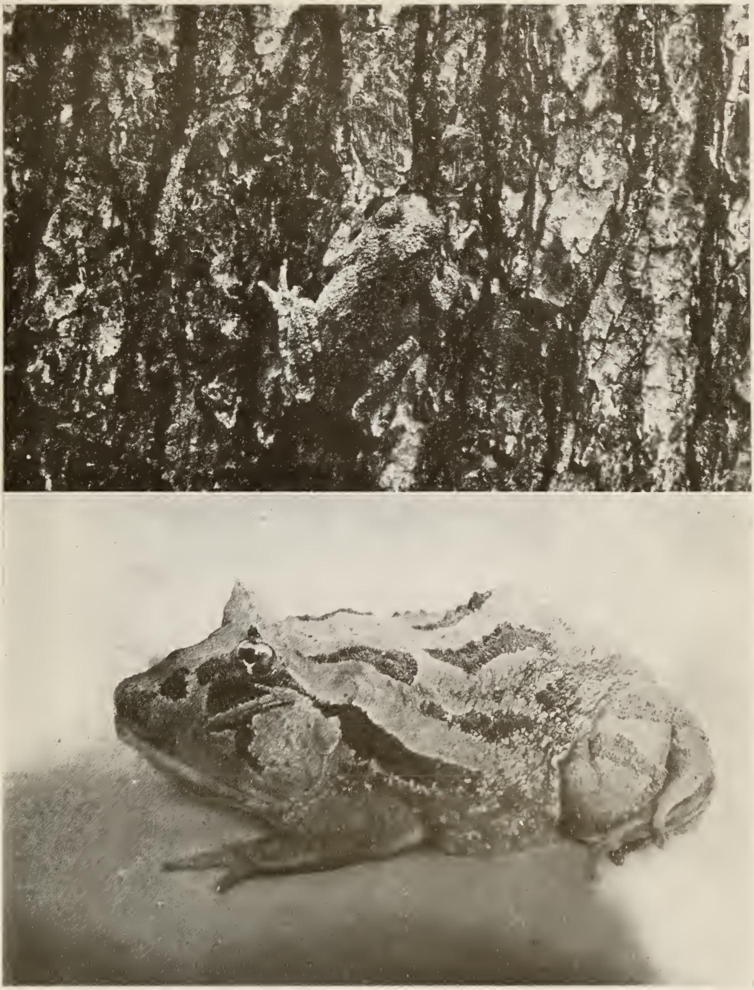
CHAPTER IX

THE DEFENSES OF FISHES

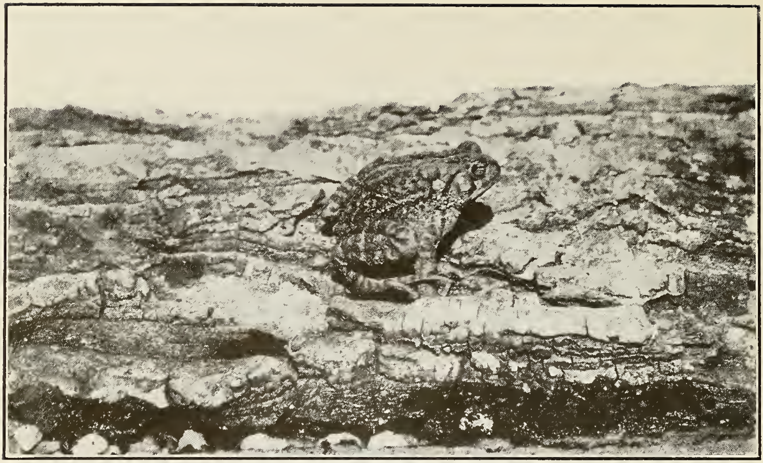
A WORLD by itself. That is the picture to be carried of the ocean floor. Depths of five miles, mountain ranges of slopes as sinister as the Himalayas, dense jungles, rolling plains and meadows, canyons with caves and shattered ledges, and deserts.

Light and temperature vary according to depth. At lesser depths there are floods of sunshine; deeper, there is the effect of twilight; and lower still, the pale light of breaking dawn. There are depths of utter darkness, even though a sun shines far overhead, and in such depths temperatures range close to freezing, though a tropic ocean rolls at the surface. At all levels, under all conditions, there are legions of fishes. Over twenty thousand kinds have been discovered and there may be as many more.

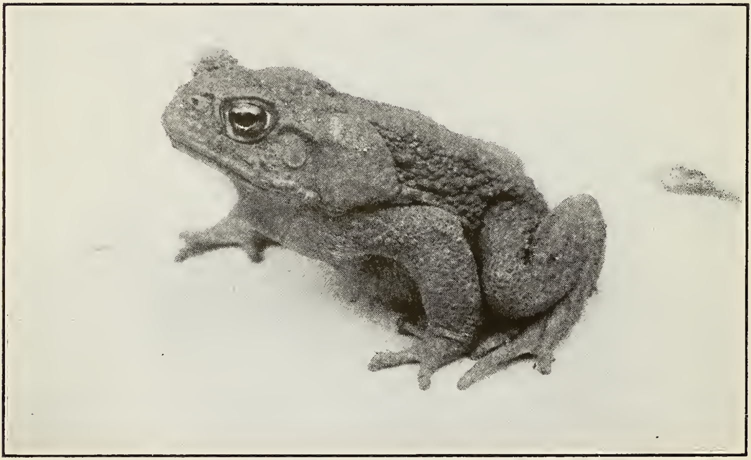
The seas form the cradle where life began upon the globe. All air-breathing animals, large and small, are linked to a long procession of ancestry,



Protective Resemblance Among Frogs. The upper figure is a tree frog of the United States. Beneath is a big forest frog of Brazil, which nests among fallen leaves and blends with their hues. It has strong jaws and can inflict a painful bite.



The Common Toad. Interesting from its history of carelessness in starting its tadpoles in evaporating pools. Such hazards are balanced by enormous numbers of eggs.



Marine Toad. Widely distributed in the American tropics. The large gland behind the eye contains a viscid poison. There are smaller toxic glands on the skin.

going back to pioneers that slowly became adapted to leave the seas. The succession of relationship of land and sea creatures has been stretched beyond points of conjecture. But there are traces hinting of transition, although too complicated to enter into this story. When chains of relationship have been remotely lost, we speak, in modern terms, of "unrelated forms." Hence when the defenses of land animals resemble those of marine creatures, we use the term "parallelism without relationship." It has cropped up in this narrative.

We come to it again with the fishes, of the seas and of fresh waters, their protective devices more elaborate than with land animals. Consider the range in size among fishes, from sharks over forty feet long to minute kinds, a half-inch in length! Here is greater diversity than among any class of animals on land, greater difference than the bulk of an elephant compared to the shrew. The mammals may top the diversity if the whale is thrown in, but we refer to land animals.

Mimicry, camouflage or confusion of outline, momentary changing of color, armor-plating, spine armament, spiked and stabbing fins (some highly poisonous), toxic skin secretions, elongated piercing head weapons, powerful teeth, fearsome decoration, power of almost incredible speed, or leaving the water to take flight, to climb about on land, are among the defenses of fishes; but they have acquired something else not known among other living creatures of the globe. That is the power to generate and hurl electric shocks. This exists among unrelated kinds in fresh waters and in the sea.

As to egg-laying and care of eggs there is a similarity between fishes and amphibians, two types of parents: the careful and the careless. Methods of the former are more ingenious and detailed than among amphibians; of the latter, and these mostly of the marine types, eggs may be laid to a number of millions.

With the power of some fishes to deliver electric shocks, I have had experiences which were successively astonishing. This power, at least with the South American eel, seems to be primarily used to snare prey, but is of high efficiency in defense. Some small, active fish were placed in a large enclosure of quite deep water with an electric eel. To have pursued and caught these fish would have been a hard job for the eel. The species is not very active. It swam slowly toward the fish, which were inclined to huddle. When about four feet from the outside, marginal fish, a shock was hurled through the water. There was no mistaking that. The fish jumped in distress and darted across the pool—except four or five nearest to the eel. These floated stunned and helpless. The eel swallowed all of them. As the fish huddled again, the actions were repeated. The eel had no difficulty in obtaining a full meal.

The strength of the shocks from a four-foot eel is unbelievably severe—unless one has experienced them. My first experience was by contact with a small eel—less than a yard long. It happened in a dark basement, where an itinerant animal peddler asked me to inspect his stock of odds and ends of reptiles and birds, all distressingly dirty—a condition not now tolerated among animal dealers. There were some reptiles which I listed to be taken, and a tub of filthy water. Holding a light over it I was unable to see what was in the tub. I knew that whatever it was, it couldn't be poisonous, so I reached in to gently raise the miserable occupant to the surface. The man didn't warn me. Maybe he thought I had been too smart in hauling poisonous snakes out of their boxes to look them over; he had showed terror until they were put away.

At any rate, my hand came in contact with something smooth. I shoved my fingers under it until my palm supported it, to bring it upward. It was then that the occupant of the tub turned loose a shock I shall never forget. My hand was jerked upward and my arm felt as if I had wrenched it.

One of my keepers was once repairing the framework of a tank containing a three-foot electric eel. He thought there was no danger of getting a shock unless he touched the water. There was the tapping of a screw-bolt into place, then turning it down with a screwdriver. It was while the keeper was doing this that the eel turned loose his charge. From my office I heard a shout akin to a yell of agony. The screwdriver was hurled over the keeper's head.

On another occasion a group of visitors was given a demonstration which showed me that electric eels should be exhibited under "insulated" conditions. It was early morning and the floors of the building not yet dry after their hosing. A descriptive label denoting the character of the electric eel had attracted six or eight visitors, huddled about an inquisitive person who was tapping on the glass. Suddenly the observers respectively executed a jump or went into jig steps. The eel had rolled out a shock that ran down the table legs and spread over the wet floor. To me the thing was mysterious. This wasn't like ordinary electricity where you had to make contact on a definite line of travel to get a jolt. The eel electricity seemed to radiate and jump into you. In Brazil I was told that the really big eels, six feet long and half a foot in diameter, can so stun a human swimmer with a single shock that the victim may drown, and even horses crossing rivers may be fatally shocked.

One of the strangest things about the electric eel is that while its form is symmetrical, its body is very short—less than a foot long in a six-foot specimen. It is in the long and solid tail that the electrical generating muscles are mostly situated.

There are electric catfish, large and small, and a powerful ray, a large flattened marine type, with whip-like tail.

C. W. Coates of the New York Aquarium, in association with R. T. Cox and L. P. Granath of the Department of Physics of New York University, have recently gone into studies of the electric eel and presented a paper of much technical detail with charts and photographs showing measurements of the discharges on recording instruments.* They show that the electric pressure of shocks may run as high as 300 volts.

In a less technical article by Mr. Coates, published in one of the Bulletins of the New York Zoological Society, there is a discussion of studies of electrical fishes exhibited at the New York Aquarium. It is explained that the electric organs of the eel are known to be three pairs of muscle-like tissue, the chief of which extend from just behind the head almost the whole length of the body on each side of the backbone. The secondary organs, called Hunter's organs (so-named after their discoverer), are smaller and run parallel to these, but closer to the anal fin. The third electric organs are called the Bundles of Sachs (named after another investigator) and are located along the large electric organs in the latter half of the creature. It was indicated that eels could regulate the power of shocks and that specimens much disturbed and throwing off many shocks might become exhausted of electrical power and require several hours before they could again generate a supply.

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* "The Electric Discharge of the Electric Eel *Electrophorus electricus* (Linnæus)," C. W. Coates, R. T. Cox, L. P. Granath. Zoologica, Scientific contributions of the New York Zoological Society, Vol. XXII, Part 1, April 1937.

Mr. Coates explains that the discharge of electricity by one eel does not affect other electric eels, they probably having a tolerance for each other's shocking power. He says:

"The discharge of electricity by the electric catfish, *Malopterurus electricus* of Africa, however, causes considerable disturbance to other electric catfish within range. This phenomenon has been noted since the first observation of electric catfish in aquaria, and all subsequent observations seem to bear it out. Recently, tank space being somewhat at a premium, we tried keeping two of these creatures in the same tank, giving them aquaria which were quite large in comparison to the size of the fish and with many caverns and holes arranged in which to hide separately. We also tried to keep one male and one female together in comparatively large aquaria, but whenever more than one electric catfish were kept in the same aquaria the net result was the same—within a week there was only one alive. In a state of nature the fish must at least pair for mating, but whether they then develop a tolerance for each other's electric powers, or cease discharging electricity, we have no present means of knowing."

These catfish do not appear to utilize their electric power to capture food, but only for defense. The electric rays, however, use their power both to stun prey and repel enemies. Whether or not they are resistant to each other's shocks, as is the eel, has not been demonstrated. They are so difficult to obtain alive that an aquarium is fortunate in being able to exhibit a single specimen.

Compared to the immense number of kinds of fresh water and ocean fishes, those with clearly defined defenses seem in the minority; yet they are thoroughly provided. As to the others, there is an animated side to this story, a battle for life against obstacles in no way approached among terrestrial life. Why the natural forces that shape development should have given a comparative few the power to hurl electric shocks or provide bony covering, spines, and induce sly methods of evasive simulation is a mystery. But among the defensive fishes are those with close-set spines which can puff up prodigiously; from the size of a goose egg they pump themselves with water to the bulk of an ostrich egg, with armament sticking out in all directions; others with array of poison spines are not to be tampered with. As to simulation there is a great number which change colors to blend with hues and patterns of the ocean floor.

The flounder, sole, brill and plaice are kinds to which things have happened to drop them in the list of simulating species. Instead of swimming "upright" as with most fishes, they have turned over and swim on one side, and the eyes to match this position have moved around to the upper side. Curiously enough, in this "turn-over" different flat-fishes have selected a "stomach" surface on different sides. Thus the brill, like its near relation the turbot, shows what was originally its left side upwards, while the plaice shows the right side as its "back," as does the sole. Such fishes, lying flat on the bottom, have the faculty of imparting a movement of the fins which stirs up sand or mud to settle over the back and fuse their margin with the surface on which they rest; but they are capable of more than that. They can quickly change color and pattern to match surroundings.

W. P. Pycraft, in one of his fine series of science articles in the *Illustrated London News,*[*] explains about the flat-fishes: "The close resemblance they display to the ground on which they are resting is very striking. It must be noted, too, that coloration may change a dozen times in a day as they move to a fresh resting-place with a different type of bottom. Mostly this coloration is composed of different shades of brown and yellow, with occasional spots of white and black. The plaice alone has red spots. This changeability is due to the presence of small globules of pigment enclosed in a thin pellicle and controlled by the stimulus of light entering the eyes and so stimulating the nervous system, which causes the contraction or expansion of the pigment-containing pellicles, bringing about now a spotted and now an almost uniform coloration, as the case may be."

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[*] *The Illustrated London News,* April 10, 1937.

As to the hazards of fish, which are legion on all sides, the greater number come from them preying upon each other. The larger among the smaller, thence down the scale, the smaller balancing the scale by feeding upon the fry of the larger. Then there are many fish-eating birds, seals and sea-lions, and in large areas of tropic waters an abundance of sea snakes of many kinds that feed upon nothing but fishes.

The predatory fishes are swift, with insatiable appetite. They gorge themselves, digestion is rapid, and pursuit goes on and on. Such are the barracudas of some two dozen species, the larger attaining a weight of one hundred pounds and darting with the speed of a projectile. The familiar bluefish, while much smaller—from ten to fifteen pounds—is equally voracious, not only eating small fish but tearing into the vitals of non-combative types nearly its size. Pycraft says: "According to expert calculations as many as one thousand million bluefishes resort annually, in the summer season, to the Atlantic coasts of the United States; and, allowing ten fish per day to each bluefish, no less than ten thousand million are eaten each day, whilst about twelve hundred million millions are devoured in the course of a season."

Schools of fish in ocean water are often indicated by the presence of gulls, but the depredations at the surface are slight compared with what is going on beneath, attacks which drive harassed multitudes to ruffle the water. Thus shoals of mackerel, whiting and herring are pursued by the predators. But the very types thus falling victims may have stomachs full of young fry of slow-moving kinds of the bottom. The mackerel is a relentless hunter of sand eels, and another gorging on such food is the cod, which in looks is anything but a predator.

As a balance against all this is the enormous number of eggs laid by many of the marine fishes—the hazards in fresh water being far less. Kyle explains that "the number of eggs varies to a great extent, but the ocean forms usually have an extremely large number. Fulton estimated that a ling contained from 14,000,000 to 60,000,000 eggs and Day cited an estimate of as many as 160,000,-

000 for a particularly large female. Eggs of the cod are in 'smaller' quantities, but even so they run up in number to 8,000,000 or 10,000,000. Recently the scientist Johs Schmidt has found that a species of sun-fish may develop as many as 300 million eggs." *

There are two distinct kinds of eggs laid by fishes which show no care for them. There are eggs that float and others which are heavier than water and lie half embedded in mud or sand, or are washed into sheltering crevices. Those which lay eggs that float produce by far the greater number. Fishes that build nests for their eggs, of reeds, or bubbles or in scooped-out crevices, with the male or female standing guard, usually have a smaller number of eggs, in some instances not more than a few hundreds. Fishes that give birth to living young have even smaller numbers. Thus there is inference, as with the amphibians, that hazard to the egg-stage is balanced by care, or, in the lack of it, by excess numbers.

Not alone are fishes engaged in a battle to evade

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* "The Biology of Fishes," Harry M. Kyle; the Macmillan Company, 1926.

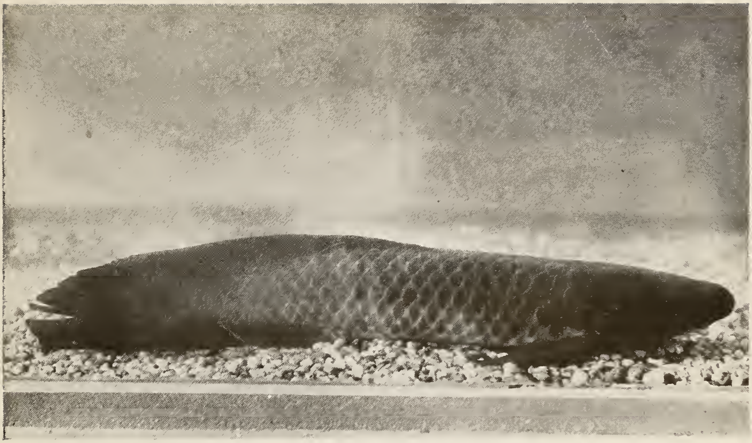
enemies; among all vertebrate types they are the most susceptible to a combination of changes of temperature, attacks of parasites and germ diseases. Severe storms temporarily changing ocean currents and bringing cold water in ordinarily warm regions, have killed millions of fishes. This was shown by the dramatic destruction of the tilefish a number of years ago off the eastern coast of the United States. This area of ocean is subject to recurve of hurricanes working up from the tropics. Such storms produce, in their advance, northeast winds in excess of a hundred miles an hour. With a synchronization of cold to the north, tidal conditions to assist the winds to sweep cold water southward, the warm waters of the Gulf Stream which are the home of many fishes may be greatly reduced in temperature. Such conditions nearly exterminated the tilefish. Millions of their bodies coated the sea for many miles. That happened in 1882, and as a market fish the species disappeared. Fishermen reported that the tilefish had been wiped out. But shoals were left somewhere and increased. In recent years tilefish showed up again off the coast of New England in the northern sweep of the Gulf Stream and this fish is now fairly abundant.

Change in temperature or variations in salinity of water cause irritating disorders of the protective film covering the scales of fishes. Once this is disturbed or becomes broken down, the fish is subject to attacks of minute parasites, disease-producing fungus or infection by aquatic bacteria. Such troubles are to be seen among captive fishes, and are difficult to treat and often result fatally. There is a host of internal parasites that attack fishes, the commonest being worms which live in different parts of the viscera.

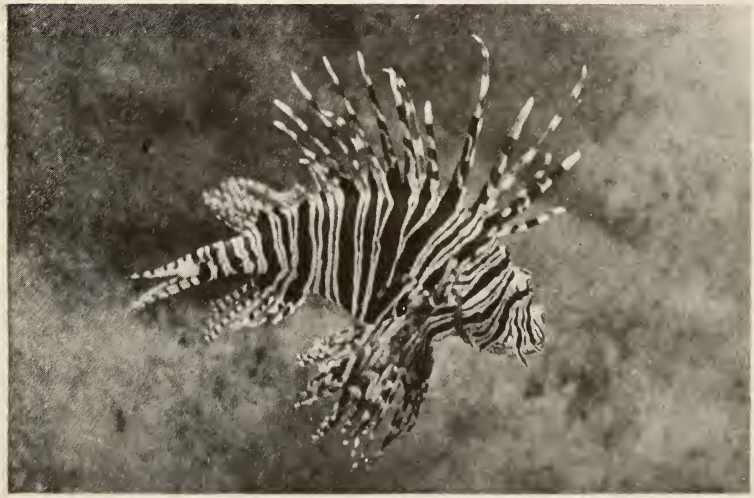
With bristling armaments of some, poison spines of others, array of simulation and camouflage, even electric shocks, those specially provided kinds, fascinating as they are, appear to be no more fortunate in domination of their races than others. There are many fishes which appear to have no defenses whatsoever. They are not particularly swift or sly. Yet they have descended, through long periods of time, from similar races. While I may have ventured conjecture here and there in this story as to weakness of races, or reasons for survival among certain types, it is rash to do more than state conditions as we find them.

In 1920 I was thrilled to receive the first living lungfish to arrive at the Zoological Park. Here was an example of unique type of survival from times when the earth was tenanted with life impatient to go places. Life had been emerging from the sea. The change from water to air-breathers was slow. Vertebrates had worked their way up rivers and into swamps, and with many gills had become modified. Transition to produce races of amphibians was under way. The lungfishes indicated a part of all this. In shape they were not unlike amphibians, but in place of legs they had two pairs of thickened fins. They had acquired what might be unscientifically called a semi-lung structure. They could live in the water like typical fishes, or, if trapped by evaporation in the swamps, could dig into damp hollows and breathe air. They had evolved from the realm of mere fishes.

Our specimen attracted wide attention. Much had been written about the surviving kinds of lungfishes. As yet they had not received much con-

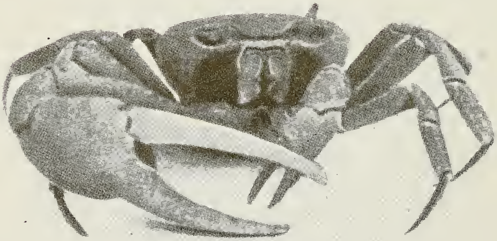


Australian Lung Fish. Surviving remnant of prehistoric times, indicating the transition from fishes to amphibians. It can live in water or breathe for years outside of it.



Zebra Fish. A phase of highly protective development. The spines of many such fishes are very poisonous.

Hermit Crab. The body is soft and elongate, hence its kind, of which there are many, uses empty shells as armament. There are changes to larger shells as the crustaceans grow.



Tropical Land Crab. Crabs are noted for their sagacity. Land species scuttle into burrows. Marine kinds have many ways of assuming protective disguise.

centrated scientific study. There were three genera, one in Africa, with three species; one in Australia, with a single species; and one in South America with one species. Hence there were five known kinds of lungfishes. They differed, some being eel-like, while the Australian was stouter, with big scales that made it look more like an ordinary fish, except for its curious fins—which didn't seem to be of much use.

Looking up the literature on lungfishes I found a mixture of checked facts and conjecture—and considerable of the latter may always surround the stranger creatures. Lungfishes were described as "living fossils" from ages of many million years ago. Nothing was attempted to explain why they had hung on so long in arrested development. They allegedly hinted of a stage between fishes and amphibians—of a slow metamorphosis that had been completed among a number of other similarly situated forms, although the change had dragged through interminable time, to be later put on as a sort of show by frogs, toads, and salamanders, in speeding through the performance from fish-like tadpole to air-breathing amphibian in a single season.

We were all set for study of the lungfish at the Zoological Park, but trouble started. Fungus spots formed on its scales and the beast stopped taking its meals of chopped beef and small frogs. We tried solutions to kill the fungus. The spots were touched with weak mixtures of permanganate of potassium, which for a time cleared the fungus, but it came back again. Then the fish was bathed in mild saline solutions. This had a beneficial effect, but the fungus returned—in new places. Within a couple of months the lungfish was dead, while visitors kept coming to see it. We were embarrassed and regarded the happening as a calamity. It was truly that, because we later learned we had killed the valuable specimen with kindness; we might have saved it. Also, to our chagrin we found we couldn't get another—that is, of this spectacular kind—as the Australian government had shut down on the exporting of the island's star freak, which was becoming rare over much of its domain. This was a pity, as the Australian species, scientifically known as *Neoceratodus,* grows to be five feet long, with weight up to twenty pounds; the African and South American lungfishes do not run so large, but are more readily obtained.

After that time the New York Aquarium received specimens of the South American and African lungfishes and took up the study of these freaks. There has always been a sort of chiding, friendly rivalry between the Aquarium and the Zoological Park—both under the management of the Zoological Society. The Aquarium contends that we, at the Park, shouldn't exhibit fishes, and we suggest that they shouldn't exhibit amphibians or turtles (the latter being reptiles). So when we heard that the Aquarium had South American lungfishes, we couldn't consistently be jealous—and, besides, at the Park we were peeved that no big *Neoceratodus* could be had from Australia.

The Aquarium did fine work in going into intimate details of lungfish requirements. Studies of habits were pushed by Christopher W. Coates, of the staff. That lungfishes retired into a mud cocoon of their own making, when swamps evaporated during droughts, was pretty well known. That they could breathe air while encased in such cocoons, which had a partial opening, was also checked. But the idea was to find how to keep these creatures alive in captive environment for study. Mr. Coates writes: " 'Fresh' water, however, is only a term to distinguish it from salt, or sea water, for anything more fetid and foul than some of the waters in which lungfishes have been found is hard to imagine. Indeed, the fish not only enjoys the murky waters of swamps and muddy streams, but demands it. Experimentally we have tried keeping lungfishes in ordinary New York City tap water—a water that, however it may have been chemically treated for human consumption, is perfectly satisfactory for a great many freshwater fishes. Within a few days lungfishes kept in clean tanks of clean tap water became covered with skin eruptions—which disappeared when they were dropped back into tanks of dirty water.

"That experiment, however, was an inadequate preparation for the surprise of investigators when they found that lungfishes that could not survive New York City drinking water could live with apparent ease and health for long periods in distilled water from which not only every impurity but every presumable necessary salt had been removed." *

When I read this résumé I remembered that every time we had treated our Australian specimen for fungus, we had scrupulously cleaned its tank and turned in fresh tap water. So now we know that they cannot be kept healthy in it. If I ever induce the Australian government to release another *Neoceratodus* I'm going to kidnap it for the Park and lay in a supply of distilled water—where it will be visible.

But as to lungfish cocoons in the mud: Observations on the home grounds and continued study of captives has brought out a great deal. The evaporation of swamps is not a regular thing, as droughts are erratic and lungfish may remain of fish-like habits for years, but when there is a drought lungfishes burrow headfirst into the ooze of the bottom and form a cell, and as the bottom hardens the head is poked upward until a small ventilating hole is formed, a kind of chimney to the apartment. In this there is further house-keeping. The creature writhes about until the cell is coated with slime from its body, this producing an insulating wall for prevention of evaporation. This is a fine precaution, as the drought may last interminably.

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* *Bulletin of the New York Zoological Society,* Vol. XL, No. I, January-February 1937.

In the laboratory of the New York University College of Medicine and in the research department of the School of Medicine of Yale University, the endurance of lungfishes breathing air in their cells has brought out astonishing facts. Breathing may slow down to one inhalation and exhalation in about every two hours' time. There, in their cells, fasting and slowly breathing, lungfishes have been kept in mud cocoons in the laboratory of Dr. Homer W. Smith at New York University Medical College for more than four years—and released from them have come out emaciated and hungry, but in active and healthy condition.

These observations are not from a few individual checkings. Dr. Smith brought ninety-six lungfishes from Africa in 1931 for experimental purposes. The New York Aquarium co-operated in the problem of deciding upon the best mud medium to start lungfishes on their long periods of "drought" dormancy—into which the specimens entered without hesitation.

Encased in the mud cell strange things happen. Instead of absorbing fats, as do hibernating mammals in a dormant stage, the lungfish absorbs muscular tissue and after an extended period may lose half its bodily weight. But in a cell, nearly sealed, there is an accumulation of wastes in an animate body, and over a long period the checks bring out remarkable figures. Coates summarizes the experiments:

"Urea continues to increase, of course, so long as tissue is being consumed, and eventually after long æstivation the urea concentration may grow as high as 10,000 parts in 1,000,000. In most other vertebrates, toxic uremia sets in when the concentration is about 20 parts in 1,000,000."

So there is a partial story of lungfishes. What their breeding habits are and possible protection of their eggs and young remains vague. But we know that in a state of partially suspended animation they can rest for years, that they pass off such conditions as uremic poisoning—using literal terms

—in a gesture. Without speculation, but considering established facts, there appears to be reasons for the survival of a few kinds of lungfishes from the dim past. Their halted metamorphosis between fishes and amphibians, however, will ever be a mystery.

CHAPTER X

SMOKE SCREENS, POISON GAS AND CAMOUFLAGE

DURING a visit in Italy a vista of animal life was opened to me of a kind I had not studied, but which I have since made intimate contacts with and recorded in motion pictures. It has a host to select from, too varied to attempt classification in these pages. The actors induced to perform were the invertebrates of the seas.

It started with two demonstrations in the big tanks of the Biological Station at Naples. The bottoms of some of the tanks looked like flower gardens with brilliant asters and chrysanthemums. The effect was produced by beds of anemones. The staff officer showed me some cuttlefishes, soft cylindrical creatures, seemingly ideal prey for big, predatory fishes. The scientist thrust a stick into the water and stirred the surface. Things happened beneath, instantly. From each of the cuttlefishes shot a cloud of jet-black fluid. It issued like a ball of smoke and was accompanied by the waving of bunched arms on the anterior part. Within a few seconds the lower portion of the tank was clouded. Visibility was zero at six inches.

"We wait for the tank to clear—there is water circulation," said my guide. In a few minutes I could look across the tank, but the cuttlefishes were gone. Hidden by the cloud, they had burrowed into the sand.

"Such animals have been doing that for a million years," declared the scientist, "and only now the human tries the same idea, with the smoke screens in the navies!"

Another thing that stood out in that visit was the performance of a crab. He was a good-sized crab, but I had to look close to locate him. His shell was the hue of the sand, which was generously sprinkled with tiny white shells—smaller than one's little fingernail. The trouble in locating the crab, even though I followed a pointing finger, came from a number of the little shells sprinkled over his back.

The stick was inserted and waved over the crab. Agitation of the water swept the shells off his back, but, with the disturbance over, the crab started to pick up the shells with his pincers and replace them.

"And he is careful when he walks to have some shells or pebbles according to the kind of bottom he lives on," was the explanation.

Here was the start of study of marine invertebrates with intention of recording such things and comparing them with the actions of land invertebrates.

It is a joy to plug on a problem with such possibilities. I learned that the Biological Station had made films of the life in the Mediterranean and I obtained some of these for guidance at the home laboratory. Then came a visit with the Prince of Monaco, noted oceanographer and founder of the Oceanographic Museum at Monaco, where there was another fascinating aquarium. The Prince was interested in the idea of making motion pictures of comparative habits and gave me some fine suggestions. He had surprising versatility. Ruler and executive, his scientific works of high international importance, he also had keen mechanical knowledge. He clarified a point that had been rankling; that is, the type of construction of studio tanks. These he said I could make myself, the bottom of plate-glass, then upright corners of standard 2 in. by 4 in. timber bolted together and spanned at the top with threaded rods. The sides would be of plate-glass, its thickness contingent to the amount of water the tank contained. To make the tank waterproof, modeling clay could be used and as soon as the clay was in place the tank was ready.

The tanks were made, for separation of different kinds, and arc-lights flooded in from the sides for photographic illumination. Collections were installed, an old street watering cart being used to bring sea water from the Long Island shore. I waited for my marine menagerie to settle down and begin to act natural; to feel at home. Some experimental focusing was tried. The only trouble was the low-mounted camera, making it necessary for some of the sighting to be done while lying on one's stomach, but such had to be. Tanks mounted on uprights would have had to be of quite different construction, and of prohibitive cost. The outfit I had could be quickly dismantled.

One night after trying experimental shots and finding it too soon for normal actions I was resting, amid conditions that might not have seemed dignified for research. In dungarees, tilted back in an old chair, with my feet on an electric rheostat, it occurred to me that the living and dying of billions of specific, small marine forms had tremendous importance in changing the contours of the world; in the building of islands and remodeling the shores of continents. This idea, I realized, was not a novelty by any means. Many others had thought about the work of coral polyps, written about it, lectured upon it. Now, sitting alone, with a parade of hermit crabs crossing a sand mound, the waving of bright-hued tentacles in another tank, and a mound of moss-covered rock in another, with small forms darting here and there, the importance of corals, stimulated by the ocean flavor of the studio, was impressive. The thought had to be satisfied. I went into the library and lugged out a bulky, old French book that had fascinated me when I was a youth.

Sure enough, it had a chapter on corals, authenticated by references to technical authorities, but embellished in flowing French. Pouchet was the author and, God bless him, that was the kind of reading which as a tired man I wanted. More of it might be applied to technical subjects never brought to light except in drab, heavy terms.

The summary of my reading produced a fascinating picture of myriads of tiny forms which dominate large areas of oceans. Small creatures which collect lime from the waters and with it form little cylinders in which to snuggle when they rest or are frightened. And as they die their solidified deposits form the foundations upon which others continue to build. Their work goes on, a continuance of death and struggling life. The mounds and hillocks rise. Parts of the oceans formerly navigable for ships show foaming breakers over the rise of coral formation, this calcareous matter built by fragile creatures, spangled over innumerable pittings like semi-microscopic flowers.

In the warmer oceans these coral polyps abound. In the regions of the South Sea they have built about three hundred islands with area over 20,000 square miles. At the approach to the Maldive Islands they form great masses of not less extent than the Alps. They have built a barrier reef to a length of four hundred miles along the shores of New Caledonia and another of over a thousand miles along the northeast coast of Australia. That latter imposing ocean structure is estimated to be thirty miles wide in parts and to cover an area of 200,000 square miles of ocean floor. Over the top of this submerged reef is a scene of varicolored beauty. Corals of many kinds producing calcareous formations, huge etched globules, bowls with convoluted margins, radiating sprays and branches of brittle lime from which the delicate spiracles of polyps nod or contract, a garden of forms that are brittle but on a foundation built and building by other forms, a surface of great beauty but with a foundation that would tear into the vitals of the stoutest vessel.

These reefs withstand surges of ocean that would annihilate any works constructed by man. Many of the beds are of great antiquity, and still growing. The rate of growth is problematical and in debate. The coral polyps are thought not to be able to live and endure ocean pressure beneath several hundred feet, but some ocean beds appear to be slowly sinking and the tiny creatures continue their upbuilding as the myriad limy homes of past legions recede. Again, upthrusts from volcanic disturbances force the structures above the waves to form islands.

The food of the tiny polyps consist of floating debris. Darwin defines them as cleansers of their waters, and certain it is that where they exist the oceans are crystal clear. Their enemies are many but their legions continue to dominate from the point of vast productive numbers. Strong-jawed fish browse upon the living surfaces, tearing away the polyps, injecting but finally ejecting their gritty cells. Small creatures bore into the cells. The lower strata of the coral banks, or graveyards of the polyps, serve as resorts for innumerable sorts of the smaller sea creatures, for here are holes and crevices for shelter. A number of such adapting kinds have assumed the colors and rough surfaces of the beds, hence their life and simulation make them a part of the coral reefs.

These were stimulating thoughts. That old French book made me ponder about some of the heavy tomes scattered around the laboratory.

Their expressions about habits lagged way behind extensive details of classification analysis.

Much was learned in that laboratory delving into habits of ocean life that was new to me. All of it has been described here and there, scientifically and otherwise, but I have not seen its continuity in readable terms, as I enjoyed it.

The best actors on those film records were the crabs. Among all creatures of large or small size, vertebrates and invertebrates, that I have seen, they showed the most ingenuity in evading enemies. Four kinds were the actual demonstrators and I have since learned that they but indicated a long list of similar devices.

There was a stout-bodied crab with wrinkled shell and heavy, strong pincers. He was a sand-colored creature, protectively colored, but this fellow was not satisfied to snuggle into a hollow and thus take a chance. If he moved from one spot to another, it was on the run and continuously long journeys were not attempted. There would be a rush, then the crab would stop, settle close to the sand, when the strong pincers would be thrust forward. They performed dual service. They shoved sand outward and upward, and at the same time thrust the opposite edge of the shell into the yielding medium. It was a case of quickly "digging in" until the top of the shell was nearly level with the sand. From this position the goggle eyes, on their stubby stalks, served as small periscopes to survey surroundings. Amid bits of debris on the bottom the stalky eyes were anything but noticeable. From this position the next path of advance was indicated by point of the eye-stalks. Then, with the course clear, no moving forms to be seen, the shell was thrust from the sand and there was another run toward the destination. At the final stop the crab dug deeper and if frightened pulled its eye-stalks downward into cavities of the shell.

Quite another kind of defense was demonstrated by my hermit crabs—one of a number of similar species, both of the sea and terrestrial kinds. The origin of this clan of crabs, elongate, soft and delicate of body, is a mystery. On the anterior parts, the legs and pincers are hard. To drag the soft body over rocks and gritty sand might scratch it. And what a delectable mouthful for predatory fishes! So hermit crabs seek armor-plating for their bodies by selecting empty shells of snails into which the body may be fitted.

There is plenty of material for such housing, as the shells of the many snail kinds range from small to medium and the size of a melon. Hermit crabs thus clad, by means of their strong limbs can readily transport the armor—in fact, can run with it. Attacked, they squeeze the body into the shell and clasp broad pincers across the opening. The pincers fit so tightly that the encased crab is a hard nut to crack.

My hermit crabs were a fussy lot. Changes of shells take place with growth; and it was necessary to give them the right kinds of shells and a variety of sizes. The shell-changer is meticulously careful about the fit and size of the aperture, as the crossed pincers must plug the orifice. Some of the old codgers, in shells the size of an ordinary ball, would carefully ransack the shell-heap in making a change. Their actions were crafty, but conducted with great care. A crab would issue from its shell, prepared to "try on" another, and its soft gray body seemed incongruous support for hard legs and pincers. The goggle eyes roved about in trepidation. At such a moment the slightest disturbance would send the crustacean darting back into the old shell. With the coast apparently clear the crab issued from the old receptacle and backed into a new one. There was much heaving and trying it out, like a man with a new overcoat that might feel a bit tight. There might be an unmistakable expression, "No, this won't do!" Another shell was tried, there was more heaving, then a motionless moment while the goggle eyes seemed to ponder. Yes, that was a fit and the crab walked off in new apparel.

Another phase of crab strategy was covering the shell with objects to disguise it. This was seen among unrelated crabs, some with stubby shells and short legs, others of the long-legged, spider-crab species. A little crab of the former shape, half the size of a man's hand, walked around with a dead sponge on his back. I understood that his specialty ran to sponges, which are abundant in many areas of oceans where they live and die on vast beds—the sponge banks.

As our supply of sponges—of the crab's size—was limited, the disguising apparel was forcibly removed from the creature's back. It was concave where it came away. Evidently it was this dented kind of sponge that the crab sought, as it had fitted snugly over its shell.

The sponge was pushed to one side and the flustered crab disposed near it. There was little hesitation. The disguising object had been removed. The idea was to replace it as soon as possible. The crab went to the sponge and rolled it over and over. There was quite a tussle. The claimant butted against it and rolled over with it like a wrestler. The job in replacing it was not easy, but determination was unmistakable. Five minutes went by; adjustment under way. Then, in motion of pincers that recalled human actions of firmly settling a hat in a wind, the sponge was jammed over the crab's shell again. Thus attired, the crab ambled off, defying enemies to choke in picking up such a mouthful. Coming to rest, it withdrew its limbs. A dun-colored sponge was all that was evident.

Such were the crabs that I considered particularly deceptive decorators. Spider-crabs demonstrated similar though more temporary measures by sprinkling their backs with tiny shells or pebbles picked by their slender pincers. They reminded me of mechanical things. The pincers were wonderfully dextrous, picking up particles, elevating them over the shell and dropping them These movements looked too unnaturally stiff, symmetrical and precise to go with animal forms; they were like the action—in miniature—of ditch diggers, or steam shovels. Scientist friends tell me that I have only peeked into the doorway of the masquerading parties going on among crabs.

Mollusks is a term that may seem tame as regards thrills in the fight to live. It suggests oysters and clams, their teeming numbers assuring continuance of their races despite various inroads. But among the mollusks there is a field filled with high points of interest. Not only are there immobile kinds, slow-moving types like the gasteropods, fast diggers though encased in pretty shells, there are kinds in shells that bore into rock, fast-swimming kinds and big predaceous species—monsters, in fact. Mollusks range from shells smaller than a man's little fingernail to the hideous shell-less octopus and giant squid, the latter over fifty feet long.

It may seem far-fetched to place the passive oyster in the same class with the devil-fish or octopus, with sucker-studded arms, staring eyes and beak like a bird of prey, but both are mollusks. The high specialization and activity of the larger, compared to the other, encased in a shell, are points for much detailed reading. I am not a specialized oceanographer, hence will not enter into classification of salt-water mollusks, but merely reiterate the tremendous difference between a minute periwinkle and a tropical devil-fish with twenty-five-foot spread of writhing arms. In studying a marine menagerie I brushed contact with widely divergent mollusks. There are plenty of subjects for selection. Science lists over 80,000 kinds on land and in the sea.

The ability to get about, either in deliberate travel or quickly to evade danger, is surprisingly varied. Mollusks are provided with what has been called a "foot." The snail kinds, large and small, have a shell of single, cave-like structure from which the foot may be extended and stretched lengthwise. The effect is of an animal crawling on its stomach, hence the grouping of these kinds under the formal term of "gasteropods." They appear to crawl on their stomachs. Most of them seek defense in withdrawing into their shells and closing a hard flap over the orifice. This works out well enough with smaller enemies, but many snails are gobbled up by the larger predators and their shells crushed by strong teeth. There is a large lizard in the South American tropics, *Dracæna,* with jaws constructed to feed upon land snails. It has powerful, molar-like teeth, which are unusual among reptiles. I have not been able to induce this lizard to eat anything but snails. Such specialization exists among fishes. The quicker the snail grows and acquires a shell that is hard to crack, the better. As an outcropping phase of protection against such enemies there are snails with shells that bristle with ridges that can cut like broken glass, and others with spikes that stand out in all directions.

Not all the snail kinds "crawl like a snail." With some the "foot" may be suddenly contracted and the creature leaps away, or the "foot" may be provided with a strong claw which is hooked into the sand, enabling the owner to jerk itself forward or sideways in jumps that are startling in their agility. Such actions provide good chances of plunging into the cover of aquatic flora.

But the allies of snails cannot uniformly depend upon retreat into a shell. Many have but vestigial shells, practically none at all, and are elongate, stomach crawlers. Among them there is mixture of protective coloration, slimy or distasteful body coating, or ejection of irritating fluids. One kind stands out in my marine studies. It was of a species we called the sea "hare," a lumpy mollusk, fleshy, and to our eyes an enticing object for big, hungry fishes. Its shell was mere pretense of the name, simply a plate covering the back. Two flappy protuberances at the forward end were like rabbit ears.

It had a habit of ascending the glass to the surface, thence stretching its flattened foot along the surface. By some combination of contact of the foot with the surface air the mollusk swam slowly, its body inverted. Thus seen, it was seemingly defenseless and foolishly rash; but it had a technique all its own. Frightened, its swimming foot was contracted, breaking contact with air at the surface.

The creature sank, not rapidly, but with the waving of its hare-like "ears." As it went to the bottom it left a vaporous trail like burning cloth. On the bottom it retreated toward a shelving rock. What had looked like vapor was now a stream of viscid, milky fluid which settled on the bottom. In a moment the sand was fuming with it.

Getting to the bottom of this performance and checking the capabilities of the performer, it seems that species of its kind secrete a fluid that is irritating to the gills of fish. Here, it would seem, is one of the originators of gas attack or chemical warfare, or to put it more fairly, a defense of the weak against the strong. However, actual attacks with poisonous fumes occur among some of the larger sea creatures. Also, it has been demonstrated that some fishes are immune to such poisons. Here is a sort of parallelism to venom immunity of some of the harmless snakes, which attack poisoned kinds. At any rate, the point crops up that the sea "hare" may have troubles from specialized enemies.

Oysters and clams are called bivalves because they have two shells connected with a tough, leathery hinge which may be closed by strong muscles. Many fasten on rocks and lead an immobile life when adult. Others move from place to place or dig burrows from which they shift and change according to food requirements. All have a "foot," as already brought out among creatures in shells, but this is used for different purposes than with the gasteropods, which crawl upon it. With the bivalves the foot is of variable degrees of usefulness. With species like the oysters it is a mere frilly appendage, but with many of the clams it is highly developed to enable them to get about with great agility. To use the expression, "as stupid as a clam," is to speak incorrectly. I have been astonished at the activity of clams, their methods of digging, making burrows and rapidity of travel even beneath the surface of sand or mud. With them the foot may be thrust from the end of the shell. With a mobile species of average size the foot looks like the anterior part of an earthworm. It is a dextrous prying and boring organ.

A bed of clams decides to dig in. Things in the open are not to their liking. From the end of each shell comes the writhing, boring foot. It drills into the medium of the bottom, its end expands for anchorage; then the foot contracts, pulling the shell into the sand or mud. The anchorage of the foot is so secure that if the bottom is soft the shell darts two-thirds of its length. Progress is slower when working into sand, but a group of clams will disappear within a minute's time. Down they go, and by this same method of thrust, anchorage and pull they can travel horizontally under the bottom.

In recording the evasive actions of clams for our motion-picture records there were some amusing scenes where a big hermit crab was used as an underwater stage director. He was turned loose to prowl into a group of razor clams that had been induced to remain in the open on a bed of sand by impregnating the water with food particles. These elongated clams have a shell shaped like the handle of an old-fashioned razor.

The crab's idea was to tuck a clam beneath a leg, thence haul it into a favorable position to see if he could crush its shell and feast upon the tender interior. Through sensitivity to the commotion every clam started to bore—and the razor clam has a particularly long and dextrous foot. Drilling organs wormed into the sand and in a moment the clams were up-ended and going down. Despite the crab's speeded activity such raids were seldom successful.

In their early phases of life the bivalves furnish food to a great number of the smaller ocean forms. In infancy they are mostly shell-less swimmers. Excessive egg laying insures survival. As many as fifty million eggs may be laid by a single bivalve. Despite the excessively thick and hard shells of those that finally settle for life on rock or coral, or the escape antics of mobile kinds, life is fraught with uncertainty. Parasitic borers penetrate shells, and such enemies as starfishes, of which there are about 5,000 kinds, attack them in unique fashion. The thick shell of an oyster and its firmness in closing is met by a kind of strength test developed by the starfish, which overpowers the bivalve's most desperate efforts. The starfish fastens to the top of the oyster, then attaches its suctorial feet to the under edge. From this position it starts a long and relentless pull. If the action were a speedy strength trial the oyster would win, but it is a test of exhaustion. The pull of the starfish is prolonged beyond the endurance of the oyster's closing-muscles. The exhausted oyster succumbs and, weirdly enough, the starfish turns its stomach inside out in thrusting it into the opened shell to consume the soft parts of its prey.

Starfishes are particularly fond of scallops, as they are more readily opened, and the two hundred or more kinds of these pretty shells commonly decorate the ocean floor. Subjection of scallops, however, is not such an easy matter. The scallop must be stalked, as it can swim. To use the term "sleeping" may seem far-fetched as applied to a scallop, but certain it is that the slow-moving starfish must catch its prey at the equivalent, or unawares, as its arms start to embrace it, for the scallop can be off with a hop, skip and a jump. It has an active closing-muscle—the only part of the scallop we use as food—and this can open and close the shell, which takes in water and as quickly expels it, producing a spasmodic rocket-type of propulsion. The scallop may go hurtling upward, then travel a fair distance horizontally, or skim along the bottom so fast it leaves a cloud of sand or mud in its wake.

Thus the empty shells cast up on the beaches hint of battles that are going on beneath the waters, battles lost with such reminders, but representing myriads that are carrying on. Devices are many. Pretty shells containing animal life do not simply lie about on the ocean floor. The ways of bivalves radiate into many channels of fighting to exist. There are kinds whose drilling foot, aided by rasping edges and melting fluids, bores tunnels into rock. Such are the ways of the pholades of the warmer seas.

If one leans over the sea wall bordering the esplanade of the Government's Hotel Washington, on the Atlantic side of Panama, there is a fair chance of sleuthing into the ways of ocean life—if the observer is patient enough. That was my position one late afternoon, dressed for dinner in starched whites, but I was lucky enough to see something that swung my studies back into soliloquy until interrupted by an escort sent to gather me in.

At some parts of the day, the water along that sea wall, although crystal clear, is difficult to see through owing to ripples. They deflect downward, radiating beams of light, and these play on the rocks of the bottom. The effect is of moving dapples beneath, corrugations of clarity and sky reflection, making the bottom so ill-defined that little can be seen except occasional, darting fish. On this near-sunset time, in still, tropical heat, the ripples were gone. The bottom showed almost as clear as if no water were there.

Fortunately timed for my entertainment, two writhing forms issued from under a rock. They were yellowish and distinct. For a moment I didn't know what they were. They looked like a pair of eels backing out for a prowl, but they were joined by more eels, until four of the undulating forms were in sight. Then the solution of the sinuous picture was disclosed, a lumpy body gliding out with attachment of eight of the waving members. So that was what it was—an octopus—not a big one, as with a bit of doubling of its arms it might have fitted into a dishpan; but it was a fearsome object at that. Its big eyes seemed to stare in all directions; its tentacles reared and showed the cup-shaped suckers beneath. It moved like a great spider with rubbery, jointless limbs. A fish darted by and an arm was shot toward it, and missed. I picked up a chunk of coral from the wall, leaned over to prevent too big a splash and dropped it so it would settle on the back of the apparition.

This cue was effective. As the missile touched the flaccid back a jet of black fluid clouded the water, but through it there was a flash of conversion from a huge spider without joints to an inverted umbrella in a gale. This object shot away. The octopus had utilized a combination of unique swimming motions and ejection of water from its siphon. Its retreat was under the ledgy rock.

What a difference between such a form and clams and oysters! Yet they belong to the same Class. How was it possible to reconcile such relationship? To do so was to drop a step lower than the octopus, to the sea arrows and squids. These are elongate, active swimmers. They have acquired large and alert eyes, they retain shells of their mollusk origin though these shells have become vestigial and internal. The "foot" of the shelled or slowly moving kinds has become highly specialized, split into arms provided with grasping suckers. Thus descendants, or really ascending from ancestors in shells, they have taken on habits that place them on a par with the vertebrates. Nothing in the invertebrate world can compare with them; some even rank among the dangerous giants of the seas, when the mammoth squid, fifty feet long, and the really frightful giant octopus, over twenty feet in spread of arms, are considered.

Reverting to the retreat of the little sea "hare" which blocked attack by laying down a cloud of acrid fumes, I recalled the defense of a weak creature. With the octopus there was thought of a more sinister use of poisonous fumes. It attacked the big crustaceans having powerful crushing claws, like the lobsters. Its tearing beak, like a bird of prey, assisted by constriction of sucker-studded arms, might not be quick enough to kill the crustacean before it had a chance to crush some vital part of the octopus. So simultaneous to the embrace there was a puff of disabling fumes.

Was such a creature as the devil-fish or octopus, fearsome in looks, sinister in habits, fairly immune from enemy attack? Such might be indicated by its make-up; but it had its troubles along with the rest. Strong-jawed enemies attacked it with a rush to tear its soft body and arms asunder before it could resist. Smaller enemies preyed upon its young; parasites attacked its eggs. It was here that my sea-wall deductions were interrupted.

The smaller cephalopods, as the active, eyed and hunting mollusks are called, are persistently hunted by the predators. They are choice morsels for the hungry. The many kinds, such as the squids, sea-arrows and cuttlefish, differ from the devilfish in having cylindrical body with eight to ten sucker-spangled arms protruding straight from what might be called the head. Such cephalopods have fin-like protuberances enabling them to swim forward, but rather slowly. Their speedy movements are backward and produced by ejection of water from the siphon—an organ highly perfected as compared with the equipment of their ancestors in shells. They have ink bags for producing "smoke screens." Those that live at great depth in darkness through which only highly sensitive eyes can see, reverse the effect of the black cloud in which species of the upper strata dart to hide.

They eject luminous clouds, which dazzle and confuse opponents.

No better example from the bag of tricks to be seen among them can be selected than that of the cuttlefish. This creature may be a little longer than a man's hand, and within its body is the vestige of what in ancestral forms was a shell—now no more than a flattened, limy plate. This is the familiar cuttlefish "bone" seen in a canary's cage. The cuttlefish is free-swimming, on the go a great part of its time and its large eyes make it alert for trouble. Despite keen vision and ability to move backward in a series of darts as the siphon is filled and water expelled, such watchfulness and activity are not enough according to natural forces that shape acquirement of protective devices. The smoke screen of the cuttlefish has been already described. This animal's most remarkable protection is a changing camouflage, that may be momentary, as it swims over varying phases of the bottom; over rocks of monotones, sand mixed with pebbles or among stalks of marine flora.

I have looked down at them in tanks arranged with accessories to their liking. There, within the four walls, they were located within simple lines of vision, yet with half a dozen known to be in the enclosure it was impossible to keep count of them. Two or three could be followed as they moved here and there; then by closing one's eyes, say for ten seconds' time, the slow moving forms were located with difficulty. By concentrating on one of them, the reason for this could be seen. Swimming over pebbly sand a wave of speckled pattern swept over the creature, or as it swam among reeds the speckles faded and vertical bars and dapples appeared. These changes occurred within a few seconds. Outlines were constantly being confused or broken to blend with backgrounds. It seemed to me that light, the mere reflection of lighter patches and shadows, had a great deal to do with it, an involuntary, protective measure shifting color pigment beneath ultra-sensitive skin. What might have been voluntary, or near-voluntary were almost instantaneous changes to "crazy-quilt" patterns that sometimes occurred when specimens were startled. The effect was almost as obliterating as simulating a definite pattern, for the cuttlefish looked first like one thing, then something quite different. Such manifestations were followed by ejections of sepia and clouding of the water.

The beds of lowly sea worms that live in limy cylinders readily crushed by strong teeth of the larger fishes show attempts at protection similar to that of the sea "hare." Delicate tentacles wave from the cylinders seeking minute particles of food. These are sensitive to disturbances of anything swimming near-by. The tentacles are snapped within the cylinders, thence from the homes of the tube dwellers thin threads of white fluid stream forth and, mixing with the water, form a smoky cloud. The bed of tube worms fumes in efforts to repel invasion.

The most deliberately insolent of these lowly fume ejectors is a large worm that roams freely and, owing to its thick body, has been dubbed the smoking caterpillar. At the end of its body is a whitish tube and when this species rears to confront an enemy the tube is pointed this way and that. The motions are like a cigarette being nonchalantly shifted to puff its vapors in the face of objectionable intruders. The white object shifts, then deliberately aims; there is a long stream of vapor. I have been apprised by scientific friends that the ejecting appendage may be at the posterior part of this creature, but the way it curls, so that both extremities are raised, the deliberate shifting of the tube, and the impudent puffs, definitely directed, induce me to stand by the name commonly though not technically applied—the "smoking caterpillar."

CHAPTER XI

IN THE WORLD OF MAKE-BELIEVE

OUR exploring party was pushing through a green tangle in Panama. We were looking for bushmasters, but hadn't seen any. One of the party, entomologically inclined, turned to collecting tropical grasshoppers. All of us started to help him, hoping our luck would change; often in collecting work you are liable to stumble on the thing opposite what you are looking for.

The technique of the entomologist was being copied by all of us. In collecting specimens of the *Orthoptera,* as grasshoppers, locusts, mantids, walking-sticks and the like are called, one should watch for hopping and flying kinds, peer at leaves and stems for resting insects, shake bushes and look for heavy-bodied insects to fall, and *listen* for the singing noises of the *Locustidæ.* Each species has its unique "song," produced by the males rubbing brittle patches or stridulating organs at the bases of the wing-covers. Some sing during the day and others only at night. The singers are stalked by locating the sounds. Even when close to them they may be hard to see as most of them are protectively colored and blend with their surroundings. We found it a lot of fun in concentrating on this *Orthoptera* hunt.

Two specimens among the material collected stood out in my mind. One was a huge grasshopper—five inches long—with excessively heavy, spike-studded legs. It was incautiously grasped by one of the hunters, who gave a yelp of pain. The grasshopper kicked him and the spikes made a row of oozing droplets of blood. "Some grasshopper," was the comment, as the entomologist correctly restrained the insect and held it for us to see.

The other outstanding specimen was the strangest thing captured. It was a flat mantis, dull brown like a dead leaf, with splashy white spot on its wings, like a bird-dropping. Little radial points, irregularly spread around the margin of this spot—duplicated the effect of how a soft substance splashes. This insect would not have been detected as it squatted on a fallen tree trunk, if one of the party had not decided to sit down at that particular spot and dabbed at the "leaf" with a stick. It started to run. Here was an astonishing example of what has been called "mimicry."

That particular insect got me into an argument not long after. It indicated how scientific minds grope for the whys and wherefores of eccentric development. The after episode of the splashed mantis occurred when the specimen in demise and immobile pose was mounted on a lanky insect pin in a glass-topped case containing fumigating cones of naphthalene. The depository was in the collection of one of the large institutions of learning, in the auditorium of which I was to deliver a lecture.

As is often the case, when I visit such institutions, the members of the staff suggested that I join them at luncheon. Such times are enjoyable. Specialists in all fields of science like to talk shop; recent scientific papers are discussed. I am called on, as a visitor, to give my views on developments of herpetology, the science of reptiles, in which I have specialized. Agreement is seldom unanimous, but that is where the interest of such gatherings comes in. On this occasion the entomologist hadn't been doing much talking, and I swung the conversation from reptiles to insects. He knew that, in time past, I had put in five years of work in entomology, and could speak with fair amount of knowledge. I spoke as one who writes of things observed in the field, without seeking to delineate in formal terms. I referred to insect mimicry and remarked that the Panamanian mantis which reposed in his collection was the most surprising example of simulation I had ever seen.

The reaction of the entomologist was in disagreement with some of the terms I used. My allusion to "mimicry" brought a response that bothered me, but was not clearly convincing. It led me to ponder as to why amazing instances of simulation have cropped up, but only here and there, when relatively figured among the immensity of the insect legions.

The entomologist objected to my too free use of the term "mimicry."

In the first place, he said, the term had been loosely used. Among insects it properly applied to harmless species that duplicated the appearance of stinging or otherwise offensive or specifically protected kinds. Thus there were stingless flies, that looked and acted like bees, harmless beetles that masqueraded in the forms of members of the *Hemiptera* which have sharp, poison-injecting beaks, and butterflies whose singularly precise wing-markings and flight actions resemble those of other species with nauseous body fluids and odors that cause birds to turn from them in disgust. Such were the "mimics." The term to be applied among the others was that of "protective resemblance."

"How do you know," continued the entomologist, "that the forms which have so impressed you, uniformly intend to 'mimic' their surroundings? From the actions of some, it appears that they ingeniously do this very thing, but such actions are at variance. What were the forces and what is the history behind their makeup—which is in the minority compared to the habit of others—and what good has it done them? They are no more abundant than the rest. Way back, there may have been radial development along such lines, some becoming radically awkward and dropping out. They perished, as have legions of other try-outs, mammals, birds, reptiles and amphibians. Some phases of development including hues and forms of simulation hung on and remain for us to find as star pickings. Among some we find attending adaptation of habits and actions well worthy of study."

This speech, as well as I remember it, showed a ridge on which one might stub a toe in too freely theorizing on the protective value of such phases of development. At the same time, I know that my friend has a sly way of arguing, just for the fun of starting something. As a herpetologist, I felt that arguments against an insect specialist would be weak, but in my inner mind I figured that what I had written in the past needed no revision. There were other forms of simulation for comparison. I thought of the crab which deliberately puts shells on its back and of another which totes a sponge. Here was mimicry to surroundings, or disguise or anything similar one wanted to call it, consciously performed. Certainly, such simulation was protection against enemies and the masqueraders carried on with such intent.

As a conclusion to our talk about insects, I enumerated a few of the actors I had watched in my laboratory. There were the stiff, resting positions of walking-sticks, with legs extended along a twig, the shivery motions of walking-leaves, like leaves agitated in a breeze, or moths that rested upon bark, their wings gray and dappled like the bark's corrugations and shadows.

The response to this was that I could write about these things, or explain them in lectures, as they were, but omit conjecture unless my points were bolstered by experiments that gave me firm ground for explanation.

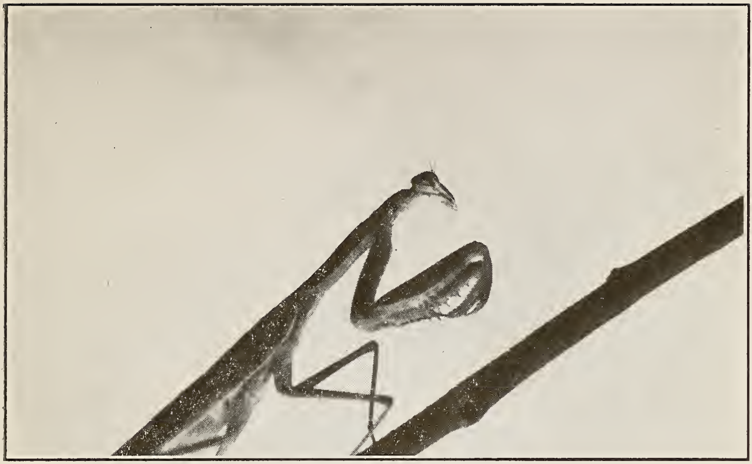
At any rate, the luncheon was highly interesting. Some of the party agreed with the entomologist, and, I think, some agreed with me that if conjecture was to be so cautiously withheld by the sympathetic observer, readable descriptions of the earth's varied fauna would be largely reduced to skeleton terms.

Such restrictions on conjecture about the habits of species was recently illustrated in my experiences in studying the actions of a vampire bat, a specimen which I had watched for months as it lapped blood from a dish, walked about on extended wing-stalks and hind feet like a big spider, or leaped upward to take flight. By gradually increasing the amount of light I was able to make motion pictures of all this, the actions reversing previously alleged habits of the vampire. With my reels to illustrate it, I read a paper before one of the scientific societies. During a discussion that followed I mentioned that the paper would soon be formally published. An elderly scientist arose and suggested that it might be too soon to publish that paper, as the studies were based upon a single vampire—possibly an eccentric individual. In the course of later studies four additional vampires behaved in the same manner.

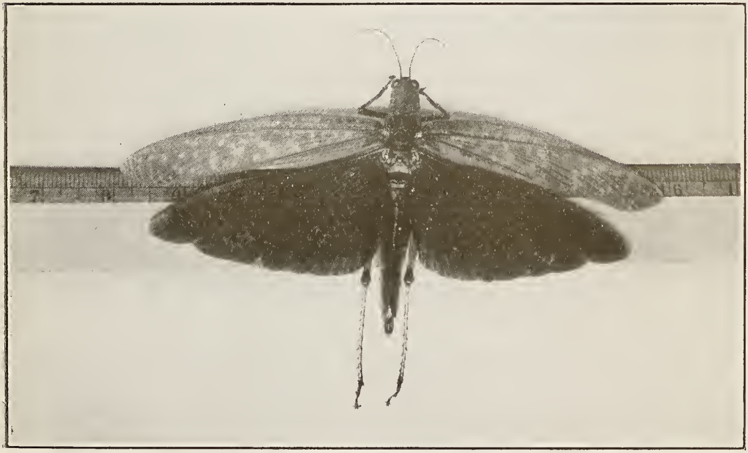
With insects there is much to write about without necessity of such subsequent checking. There are not only structures of marvelous protective resemblance to be noted without other comment than the extremes to which they are carried, but masquerading *tactics,* the use of various weapons and other measures employed for defense, and the savage attacks of kinds that repel intruders. Among all insects the greatest variety of form and hues to simulate surroundings is to be seen among the *Orthoptera,* the kinds which started our insect hunt in Panama. While the New World has a number, beside the example of that blotched mantis there being leaf-winged locusts and walking-sticks, the warmer latitudes of the Old World have the most exaggerated cases of simulation.

Grasshoppers and locusts are grouped together; they are so closely allied there is no line of definition. The more plebeian hoppers of the meadows are more or less protectively shaped and colored. Quite a few of the green kinds have pointed heads like the tip of a grass blade, while wing-covers are slender and elongate. The katydid, a big arboreal "grasshopper" (more properly a locust), has broad and convex wing-cases, leaf-green and delicately veined all over. Some of the big cone-headed locusts of the meadows, which are loud singers, as is the katydid, are difficult to detect owing to lanceolate green wings like slender leaves sprouting from the stems on which these insects vertically rest. I have stood a yard from a singing specimen, peering to locate it, and had a hard time to focus upon it.

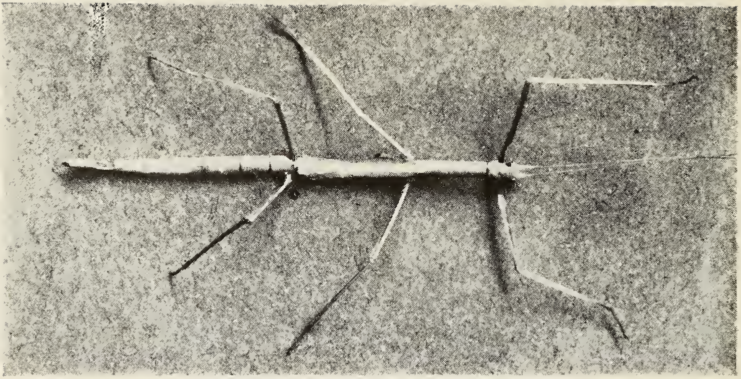
No better example of protective resemblance among the local insects is to be seen than with the walking-stick of the eastern United States. It is



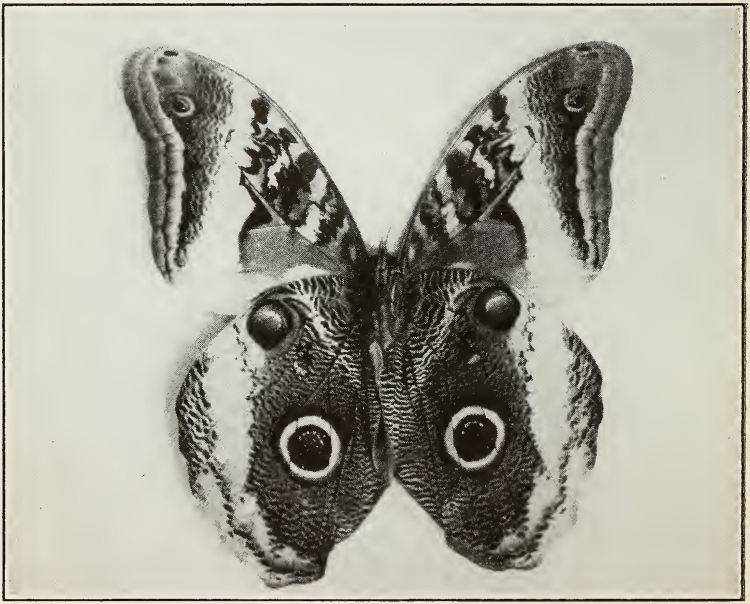
Asiatic Mantis. There are many kinds of mantids in both the New and Old Worlds. They are insect eaters, grasping their prey with powerful forelimbs.



An Armed Grasshopper. This big grasshopper kicks with its spiked legs if restrained. The spikes are so strong and sharp they can draw blood if the insect is handled by an incautious human.



A Walking-Stick. Stick-like form is common among insects. Such forms occur in unrelated groups in temperate and tropical parts of the world. Some are over a foot long.



Owl Butterfly. South American example of what has been called bogey markings among insects. The specimen is inverted to intensify the effect of the staring spots which contain light speckles producing the effect of high-lights or glitter of eyes.

rather common on small oaks. Its relationship is not distant to grasshoppers and locusts. Through the Malay islands and in northern or tropical Australia there are giant walking-sticks of astonishing structure. They grow to be fourteen inches long, as thick as a man's finger, are gray, shaggy and pitted like rough sticks; and in their actions simulate a stick by anteriorly and posteriorly stretching, and keeping close together, long skinny legs like withered twigs. A Malayan kind has acquired more eccentric imitation. Its elongate form terminates like the end of a splintered branch and is sprinkled along body and legs with sharp thorns of reddish hue. To all appearances it is a broken briar, something to pass unnoticed except to casually avoid.

The Old World tropical mantids exhibit a variety of styles in leaf simulation. There are green kinds with wings like leaves but the thorax remaining elongate and no appendages other than the grasping or "praying" fore-limbs carried by all mantids; others have a wide flare on each side of the thorax, the latter suggesting a broad central vein of this leafy shield. Thus with wing-covers like broad leaves and thorax like another leaf, insect outlines are gone. In the procession of such disguised mantids some are like dead leaves and others like live ones. One that appears to be made up of several leaves is part yellowish green and part tinged with red, like a mixture of leaves changing hue. Among orthopterous insects there are as many that resemble dead leaves, the simulation of the wing-covers being carried to such extremes that they are like old and battered leaves, chipped or cracked. The edges of the wing-cases may be irregular, or traced with *patterns* that convey the impression of broken edges. Closely examined these indentations look as if they had been skillfully painted to convey the illusion. A unique species has a patch on each wing-case like part of a leaf that has been skeletonized by minute insects or attacked by fungus. This imitation is so perfectly carried out in matching of pale hue and delicate open network of venation of a skeletonized leaf that one feels as if a magnifying glass should be used to prove that such deception can exist.

The mantids, close to a thousand species, are insect eaters, and, in miniature, as ruthless in attacking their prey as lions and tigers. Their simulation to surroundings, posed in motionless spectral positions is, of course, deceptive to victims coming their way. Their leaf-like, or with some, stick-like, appearance is of dual value. It deludes approaching victims as well as enemies of the mantids. A near relative, but a harmless, gentle leaf-eater, is the Old World's star example of protective resemblance. This is the walking-leaf, of which I have studied several batches from Ceylon. It is a satisfactory insect to maintain, two-thirds as long as one's hand, with large specimens nearly two inches wide. In form it is like a leaf; but these words must be embellished as they are weak in indicating the character of this wonderful creature. The females, which are the larger and broader are flightless, but have wing-cases covering the back. These are both heavily and delicately veined like a leaf and pale green. As a leafy shield they dominate the creature's outline, but the idea is carried to each leg, the large joint of which is flattened like a small leaf. With the fore-legs this is carried out more broadly and touched off with a ragged margin to be seen on leaves that have been nibbled by insects; and to top off the effect, as if no slightest detail should be lacking, the edges of these small "gnawed" leaves are stained with yellow—the hue of a deteriorating, injured leaf.

I reared a number of specimens from hatching of the eggs to full maturity, and in watching the life cycle saw changing phases of protective simulation.

The eggs are like shriveled, spiny seeds; the young walking-leaves as they emerge are dull reddish, wingless and glossy. Feeding mostly near the ends of branches, where the leaves are small and tender, their body hue suggests terminal buds. Moreover, they have a trait of curling the body, like the flaps or coverings that roll back as buds develop.

To provide food for my walking-leaves during the winter I had a succession of acorns planted in the greenhouse. I found that specimens would take oak leaves in preference to other kinds. A friend dropped in when I was looking at the oak nursery. Some of the acorns had sprouted and there were several leaves. When he learned what they were for and heard that my Ceylonese insects fed upon nothing but leaves, he asked if he could take one or two specimens to make an analysis of their blood. He later told me that the blood was of a very beautiful color, that a drop of it scintillated like a rounded green jewel and it was rich in chlorophyl, the substance which causes leaves to be green.

This gave us an idea. Out of doors the leaves were turning to bright shades of yellow and red. The walking-leaves were divided into several colonies. Colored leaves that were still alive and meaty were selected. We made up a cage of red, one of yellow and another of green. The effect was as expected, only far more pronounced. We soon had yellow, red and green walking-leaves, as they consumed the leaves and their blood circulated the respectively colored pigments. They were harder to detect than ever when one was leaning over the cases and making a count of the number of specimens known to be there. Under this artificial environment, however, on motionless leaves in a glass-sided case, an insect would betray its presence by gently swaying the body in little wriggles, like a leaf agitated in a breeze. This is one of the characteristics of all leaf insects, a little sideways dance. The inclination persists among captives, even in motionless air.

While the *Orthoptera* have been given prominence as having a large number of species with protective resemblance, the impression should not be gained that other orders of insects have not flaunted many members that fit into the world of make-believe. There are butterflies with leaf-shaped wings terminating in a point like a stem. When they alight on a branch the effect is of the wings sprouting from it. There are thousands of moths which when resting on rock or bark so simulate texture and coloring that the keenest eyes may fail to detect them. Bark, sand and rock-colored beetles are everywhere. The styles resembling green or dead leaves are carried through orders unrelated and remote to the *Orthoptera* where the tendency is so particularly evident. The walking-stick type of camouflage has even cropped out among aquatic insects.

As examples of typical insect mimicry, as defined by my friend the entomologist early in this chapter, there is a long procession, precise duplication of appearance carried out to astonishing degree and associated with imitating actions. Such mimicry is parallel to that among harmless snakes, the imitators of the deadly coral-snakes with rings of scarlet, yellow and black, and thick-bodied kinds marked and posing in striking coils like the vipers.

The advantages of insect mimicry can be seen among all the groupings or orders. Not only are there many examples of mimicry within a certain order, but there are insects which mimic those of unrelated orders. Among the butterflies there is an army of duplicators; and a nauseous evil-smelling, hence non-edible species, may be mimicked by a dozen or more kinds of non-nauseous butterflies, even including day-flying moths. Many of the species mimicked are of brilliant colors and oddities of pattern, with relatively elongate, or particularly short, bodies; also there may be characteristic length and thickness of antennæ. None of these details is neglected in the make-up of the mimics. In Malaya there is a bluish butterfly exuding a rancid odor, thus safe from falling prey to insect eaters. It is mimicked by a butterfly of the swallow-tail group which lacks trace of lower wing serrations or tails common to its genus. Among the so-called nauseous butterflies and their imitators there is seldom an indication of subdued coloration. Coloration as a rule is brilliant, with pattern vividly defined; "warning colors" as listed by scientists who have intensively studied such life. Investigators have noted that the nauseous kinds may be attacked by insect enemies, but so quickly rejected that no serious injury results, also that young insect enemies acquire a fear of distasteful qualities among the mimics.

What has been noted among butterflies and moths relates to mimicry carried on within a single order. Let us see what has happened among other insects that stalk in forms mimicking the members of unrelated orders. Here is even more impressive demonstration.

Defenseless insects mimic kinds with repelling odors, stings, poison beaks or glands that eject irritating fluids or fumes. The trend goes even beyond this. Kinds with weak stings mimic relations with stronger stings. Thus dressed in deceptive attire they strut and threaten like actors rehearsed for their parts. A savage wasp of Brazil has mimicking followers that are members of several unrelated groups. A large blue bug or member of the *Hemiptera,* itself possessed of a piercing beak, simulates this more formidable wasp. Its body hue, brown wings, long legs and method of turning to insolently inspect an intruder produce such a match for the wasp that it would take keen examination to tell them apart; but most surprising among the big wasp's mimics is a bluish, flying grasshopper.

The large and smaller bees have a host of mimics in the unrelated order of *Diptera,* or flies. The polished and globular bodies of the bees are beautifully matched by similar bodies of inoffensive flies. When there are bands of color on the bees, these are duplicated on the flies. Moreover these "bee-flies" pulsate the body in the manner of bees and if picked up make a motion of pressing the tip of the body against the captor with motion of stinging. An example of one of these bee mimics is to be seen in the northern United States during late summer, when it flies into houses during late afternoons and as anxiously tries to make its way past closed windows during early mornings. This fly is commonly mistaken for a honey bee. It is of the same size and similarly banded with orange. Its actions are like a bee in the constant dipping movements of its body. Close inspection will show that it has two wings, while with bees there are two pairs, the lower much the smaller. In the mimicry of a number of the bee-flies this absence of lower wings is balanced by an indentation on the lower part of each of the single wings. The effect is like the margin of an additional wing.

Many ants, which have acquired disagreeable properties in their secretion of strong-smelling formic acid are mimicked by small insects lacking any protection from enemies except the latter's hesitation to attack kinds indicated as unpalatable.

Another phase of insect mimicry, in some species among the larval stages, and in others appearing only in adults, is what has been called "bogey" protection. This consists of markings or formation to frighten possible enemies, and actions to accentuate appearance. The most startling illustrations are among caterpillars and examples may be observed among the larvæ of the common swallow-tail butterflies. The stout green body is swollen at the forward portion and there are marks like staring eyes. In front of these "eyes" is a retractile organ which may be shot forth as a forked appendage like a serpent's tongue. With the body of such an insect half hidden among leaves, the pretention of mimicking a serpent's head is startling, at least to a human, as I have noted; in fact I have involuntarily recoiled in close contact with such an apparition. The body is waved, the "eyes" seem to glower angrily and the forked organ darts forward.

Some of the elaters, or wood-boring beetles, have staring, eye-like spots on the thorax and the markings of many butterflies and moths have been described as "alarming staring spots." Tropical American species, allied to the resplendent morphos, have spots on the under-surface of the wings that in character and size are like the eyes of an owl. When resting and with wings folded over the back this staring decoration peers through the foliage.

Some day when I again visit my friend the entomologist, I'm going to ask him what he thinks about a certain South American lantern-fly, which I forgot to bring into our discussion. It is a star among these bogey or scaring kinds.

This lantern-fly is heavy-bodied and nearly as long as a man's hand. Its wings fit rather tightly over its body, which comprise about half its length. The other half consists of a bulbous head like a greatly elongated mask. The greater part of this anterior portion is no more than a tough shell. All lantern-flies, New and Old World, have this mask-like anterior, which is alleged to glow at night, but doesn't; hence a long-standing but misguided grouping of the "lantern" flies. Most of them, when resting, look like bark, and the excessively long head adds to the deception.

The South American species particularly referred to has been gifted with far different design than mere camouflage. Its long, bulbous head is "painted" like that of a caiman or South American alligator. On each side there is a row of white markings like the sharp or irregular teeth studding a crocodilian's jaws, and above the teeth on each side is a marking like a staring eye, and in advance of this another like indentation of a nostril. If a toy-maker were to design, carve and paint the ugly face of a snappy young reptile, he could make no better replica. When it is resting, half-snuggled among debris of the forest floor, the effect of this insect's mask and markings is startling. The jaws seem loosely closed as if about to snap, and the "eyes" stare alertly.

To pass this species by without conjecture, is impossible. If the effect of its markings startles the human eye, there would seem to be little doubt of a similar reaction among a goodly average of insect-eating birds and mammals, for there does not appear to be proof that they cannot be fooled by such deceptions.

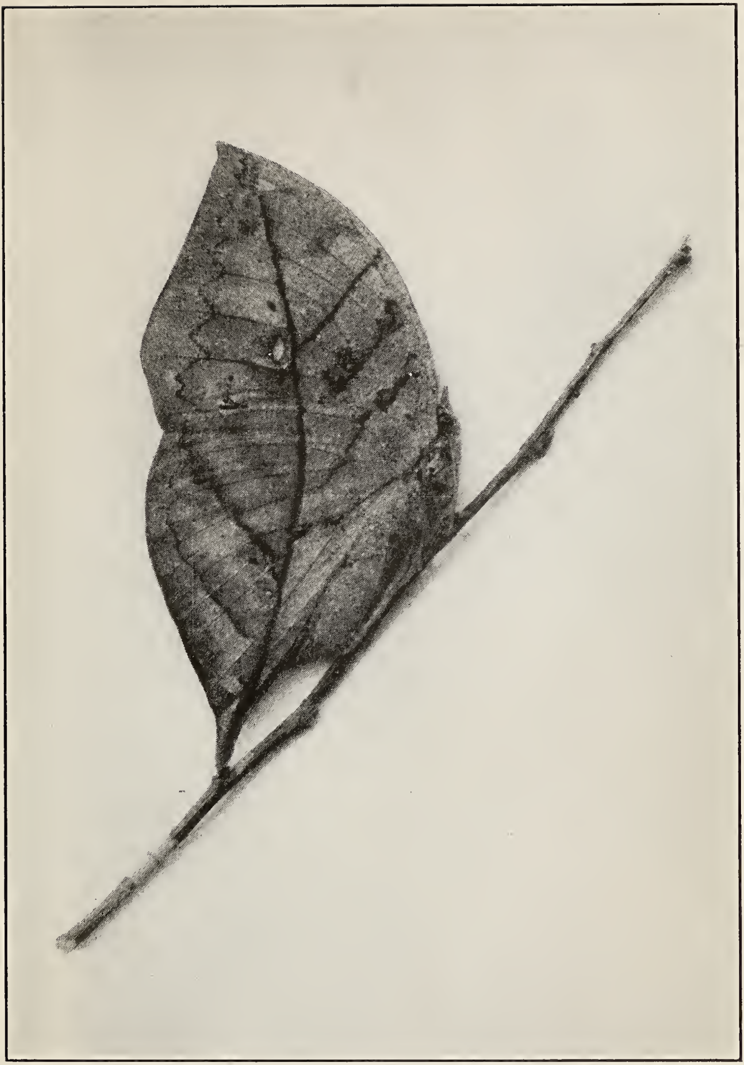
Of insect weapons and formidable defensive devices there is an elaborate array. Some have been referred to as models after which forms of mimicry have been evolved. Bristling barbed spines, carrying irritating poison, are a covering common among larval forms until they take concealment in cocoons and shed this repelling armament. Irritating hairs microscopically serrated and impregnated with acid is another covering. The stings of the *Hymenoptera,* some powerful enough to be dangerous, even to man, are well known. Keen in the powers of instant use of these weapons, many of the Hymenoptera savagely attack in defending their homes. The typical bugs, forming the *Hemiptera,* or suctorial insects, have strong beaks and are able to employ them painfully if restrained. The acid-injected wounds of the larger species are excessively painful to man and the larger animals. Acid-impregnating jaws are common among insects. Many beetles reek with strong fumes; some squirt streams of blinding fluid from anal glands. Such methods of ejection are highly perfected with the bombardier beetles, which shoot a cloud of burning gas toward an enemy, the discharge accompanied by a distinct sound, like a miniature pop-gun.

Despite defenses, insects are flanked by an army within their midst, composed of two divisions. One is composed of the outright insectivorous kinds. The other is more formidable owing to insidious attack, and of immeasurable importance to the world. Its forces are composed of insects ranging from small to minute size—the midge-like kinds the more important. Such are the parasites, which largely select the larvæ or immature stages of insect life, attach or embed microscopic eggs, and when their young hatch these burrow into the body of the host which thus becomes blood-drained and dies, but not until the parasite larvæ have completed their first stage of growth and are ready to enter the intermediate or passive stage, from which they emerge in form like their destroying parents.

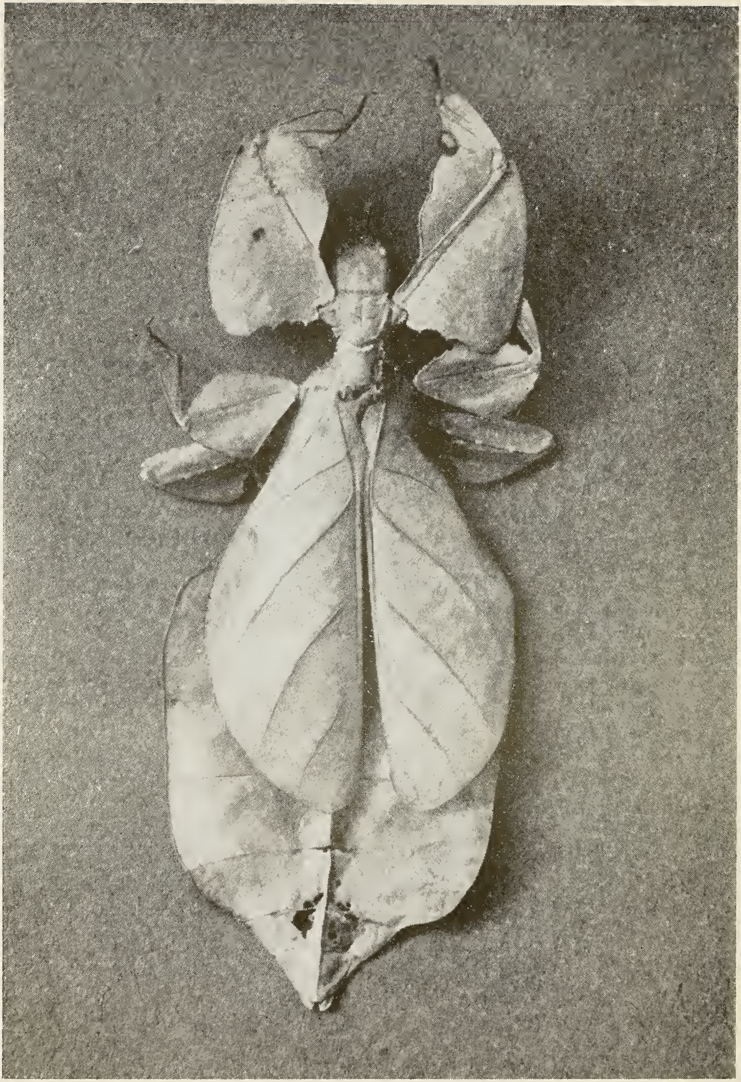
Neither protective resemblance to surroundings or mimicry help much in evading the search of parasites for their victims. They are keen sleuths, with deduction for such evasion. It has even been intimated that some of the simulating forms suffer particularly from parasite enemies. Sinister pictures have been suggested by entomologists, showing what might happen if the army of parasites slowed down; that insects might dominate the world. Here is possibly the most powerful check against their excess multiplication, outranking the attacks of the insectivorous cohorts of animal life, including the army of the spiders, and still another, the action of fungoid infections bolstered by the ultra-microscopic bacteria which impose a penalty among all forms of life.

To go into details of the natural controls of animate creation would be interminable. But we may pause to note the battle of insect life against the attacks of parasites; to see that there are definite defenses, thousands of instances, in fact.

Eggs are protected by being embedded in bark or deposited under the surface of the ground by lanceolate organs of the females, these organs called ovipositors. Eggs may be deposited in a tough frothy mass, soluble to mouth fluids ejected by the hatching young; or may be swathed under silk, which, if an enemy seeks to penetrate it, gives off acrid and choking dust. The latter also figures in the construction of cocoons protecting the larva as it prepares to cast its skin and transform to mummy-like form to await the growth of wings. All very well, these precautions, if the eggs of the parasite have not been embedded in the skin of the larva before the fortifying cocoon is completed. Some of the caterpillars of the large bombycine moths, which leave a valve at the top of the cocoon for the future moth to emerge, take no chances that parasites invade that flap-like opening. Just within it is spun an entanglement of



A Leaf Butterfly. It represents the genus *Kallima,* of India, but there are similar forms in the New World tropics.



Ceylonese Walking-Leaf. An extreme in protective resemblance. Even the legs are leaf-like, the anterior pair with notched margin as if gnawed by minute leaf-eaters.

sticky silk. If the caterpillar is once encased, without previous attack by egg-embedding parasite, its emergence as a moth is assured.

Certain African moths are attacked by parasites which bore through the sides of cocoons. When the parasite larvæ have feasted upon the body fluids of the inmate they emerge and spin a colony of tiny white cocoons of their own outside. The caterpillar of a large African moth makes an attempt to delude such enemies by pretending that its cocoons have already been invaded by spinning a copy of those of a parasite on the outside of its cocoon. These are a replica of the cocoon mass of a specific kind of attacking parasite. Here is one of the most unique delusions in the insect world. Whether it largely fools the small prowling enemies has not been disclosed by investigating scientists.

Thus is the struggle of the insects—the attacks of insectivorous mammals, birds, reptiles, amphibians, fishes, and through the invertebrates, including the battles within the insect class itself, wherein insectivorous kinds rank high in numbers. Among all sorts flit the sleuthing, destroying parasites while the world is spread with intricate patterns of spiders' webs, smothering, entangling or exhausting snarls that ages of time have brought into perfection as checks.

Where hazards against certain kinds of insect life might be inclined to devastate, rapid breeding and excessive egg-laying are counterbalancing factors. At times natural balance or checks may be thrown out of kilter, as is seen during insect epidemics, of kinds that man calls pests, which defoliate trees and devour the products of the field. Such flares induce corrective measures. Fungoid diseases, specifically destructive, wipe out multitudes in a season, or an army of parasites may breed to attack them; food plants may be so widely devoured that kinds necessary to the insects become scant and impoverished, the larvæ spin fragile cocoons, weaken and die.

Thus are corrective measures to be seen, unless a region is invaded by foreign species, accidentally introduced. The European gypsy moth multiplied to destructive millions in New England and its ravages continued for years owing to its introduction to territory where there was no specialized parasite to attack it. Its food requirements being varied, it ravished many kinds of trees. The same condition now exists with the accidentally imported Japanese beetle. Years of human effort and expenditure of millions of dollars have partially conquered the scourge of the gypsy moth, but the spreading destruction of the Japanese beetle may bring an even more distressing picture. In their native lands these species are noted as no more than normal members of the fauna, injurious at times, in spots, but not listed under the head of scourges. Time has evolved the parasitic enemies to hold them in check; trees and soils where their larvæ respectively feed carry spores of micro-organisms to slay excess numbers by disease. Thus throughout the insect world, under normal conditions, the fight to live surges to that line which is seldom broken—the line of balance or restraint which influences all forms of life.

CHAPTER XII

DISCIPLINED WARFARE LONG BEFORE MAN

WHILE loathsomely regarded by civilized man, the cockroach clan has a particularly brilliant history in the development of insect races. Fossil remnants show that cockroaches existed during the Carboniferous Period, and according to specialists in the age of the earth that was 300,000,000 years ago. The race continues, but not as mere hangovers, or "living fossils" to be seen among remnants surviving from prehistoric times; cockroaches survive in imposing numbers in all warm and temperate countries. They are largely forest insects, but some, for food convenience and shelter, have attached themselves to the gatherings of humans. The survival of the cockroach clan comes from sagacity and activity. All are largely nocturnal. They are not aimless wanderers, but have avenues of retreat from danger; they are keenly alert in sight, sound and smell and their investigations marked by cautious waving of sensitive antennæ. They fit into the great scheme of things as scavenging types. It is natural that such a strong and ancient group should give rise to races of radiating habits.

Cockroaches were the ancestral base whence one of the most marvelous groupings of insects was derived. They should have credit for the beginning of disciplined social life, of system which exceeds that of humanity; and this started before the first misfits of warm-blooded or mammal life appeared, even before the period that ushered in the larger dinosaurs.

The descendants of cockroaches, which were to assume world importance and become steadily more dominating, were small. Their rise came through a process of digestion. In some way, they made contact with micro-organisms of the soil, which in gross terms are called germs. Among such organisms, some less than a thousandth of an inch long, there are beneficial and disease-producing kinds. What the descendants of the cockroaches found were of the former kind. Cockroaches had been varied feeders, even subsisting on rotting wood.

The changing members among them, by picking up certain organisms along with their food, made wood far more digestible. Inclination furthers adaptation. Wood was everywhere a food supply. An intestinal content of micro-organisms changed tough cellulose into readily digestible sugar. There was slow perfection of this food problem permitting work under cover in the midst of unlimited supply. The use of waste products and exudates furnished colony shelters of greater security than within rotting debris of the forest. Colonizing habits were slow in building to great numbers maintained by inflexible system, but the *Termites* * were finally evolved.

Traces of their remains from rocks of the Cretaceous Period point to their being of wide distribution at that time, over a hundred million years ago; that their systematic colonies were flourishing during the age of the dinosaurs. Their rise from cockroach ancestry had been carried through a great period of time, but long before the appearance of social mammals, and interminably long before prehistoric man they had mastered the benefits of controlling feeding problems, lived in orderly colonies of hundreds of thousands, had specific casts of reproductive members, workers and soldiers. In the imposing structures they had come to build they had mastered construction of cement-like material, intricate rain-shedding devices, ventilating flues, even porous chambers akin to air-conditioning.

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* Improperly called "white ants." There is similarity of habits to ants, but no relationship.

With the world inhabited with grotesque monsters which turned their young adrift to scuttle for themselves, the dawn of construction, colonization and care of young was ushered in by insect races. But their improvements expanded. Other insects took up colonizing habits. The true ants spread over the earth. Enmity arose and among the two groups, unrelated, but of similar habits, the fighting members became more formidably armed. As defense from invasion, termites not being of warlike tendency, they built up preparedness; their soldiers were more strongly evolved to repel foes. These fighting forces were divided into several branches. Heavier heads and more massive crushing jaws were provisions of the main defending soldiers, these assisted by members waging chemical warfare. The latter had a spout on the head, projecting forward.* This was connected with a gland. According to the species this ejecting weapon could discharge burning fumes or viscid fluid upon an attacking ant, subduing the enemy on the spot. Thus have the termites held their own, and more than their own, particularly in warmer parts of the world.

Visitors first seeing tropical regions are amazed at the magnitude of termite architecture. Some structures weigh tons and rear their pointed domes high above the head of a tall human, even as high as twenty feet. One must stop and ponder to appreciate the magnitude of toil in constructing such shelters, the edifice built by hundreds of thousands of tiny workers, each carrying no more than a minute crumb of material, carefully placed and cemented by viscid exudate. But the great mounds rising from forest floors, or rearing in the savannahs, are but part of the variety of termite building. There are over twelve-hundred species of termites which build structures of different forms.

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* Classified among termites as "nasute" soldiers.

A number build nests in the trees. The mounds on the ground are pointed like peaked houses, like the acuminate tops of towers or structures with pointed minarets. Such are designed to shed the rains. The nests in trees, as a rule, have overlapping, shingle-like ridges, directed downward. Throughout the hot countries such nests are to be seen in great variety, but seldom the working termites. Their bodies are soft and delicate and hot, dry air is distasteful. Hence where routes to food or nest-building material are lengthy termites build tunnels through which they pass under cover. I have seen these tunnels on the trunks of trees in Central and South America, in appearance like tough vines adhering to the trees and wide enough for opposing streams of workers to pass. On the great trees of Panama these tunnels extend a hundred feet or more to arboreal nests.

Leaving the hot tropics large termite structures become scarcer in most parts of the world, but species of smaller colonies, hence less pretentious habits, continue to be found. There are listed forty kinds in the United States, most of them maintaining their colonies under rocks, in or under the trunks of fallen trees, and the latter, in the temperate zones, lack the precarious nature of such places in the tropics, where there is excess moisture and disintegration is rapid.

To present a composite picture of the inner chambers of a termite colony, with particular bearing upon the tropical kinds, the royal cell is of prime importance. Here is the queen, which may live many years, and a king with equally sustained life. From within this cell comes the source of the progeny to sustain and increase the colony. The queen may lay as many as five thousand eggs a day and live at least as long as ten years.* Her eggs are distributed and tended and her progeny reared by the workers. These eggs produce different casts to form the balanced colony. Normal hazard and death rate necessitate continuance of this extensive egg-laying.

At certain seasons the colony seethes with excitement. Thousands of members that have been so reared that they grew wings, prepare to take their leave. The winged members are future queens—and prospective kings are also ready for flight.

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* Checked by scientific observation.

Soon the nearby shrubbery glistens with winged adventurers—and the sun glints upon those that radiate upward and to the four winds. As is the common story with the sowing of a multitude to disseminate life, only a very small percentage survive to carry on. Bewildered by sun and air following darkness of a celled structure the liberated insects flit aimlessly. Brightness of the sky attracts them upward; they tire and flutter through tangles of surface vegetation. A swarm of such delectable, fluttering morsels stirs a host of enemies. Birds, lizards, insectivorous insects find easy prey and the webs of spiders reap a harvest; but some find shelter, more or less accidentally alighting upon the medium which gave rise to the termite races, the decaying wood of rotting tree trunks. With such destination the female termite is satisfied. She feels encumbered by her wings. Bending them back she breaks them off at a suture near their base. Each wing has an indented line at this point to facilitate the shedding. The break occurs similarly to that across a scratch in cutting glass.

But odds confront her; the chances of attracting a mate. Rearing her body she emits an enticing odor. If she is thus located by a male the pair seek shelter, excavate and seal a nuptial chamber against intrusion and within a couple of months are caring for a small family of young. The progeny grows rapidly and is soon strong enough to start work upon additional apartments and reciprocate in the care the parents have given them. Egg-laying continues and, with nursemaids becoming more numerous, the colony expands and along with growth produces defending members. The king remains a mate to the queen for life. The queens of tropical termites become so enormously distended with eggs that they are helpless to move about the royal cell, which is meticulously attended by workers, with soldier guards lurking near the entrances. The body of such a queen is like a fat, white sausage, utterly out of proportion to the workers in their busy duties around her. The king maintains his dignity in being about three times the size of the workers.

No weakness is tolerated in a colony. There is elimination of the infirm; a system of eugenics is maintained. Hence the strength and development of races. So successful are these early originators of social systems in expanding their numbers that they have shaped the development of important types of animals which subsist largely or wholly upon their teeming millions. Such are the anteaters among the mammals, which have become so highly specialized in feeding upon nothing but termites and ants that with the exception of a few flat, rear molars their teeth have disappeared, their mouths become extremely small, while a whip-like, sticky tongue of great length may be darted into crevices. The great anteater of tropical America is typical of termite eaters. The weight of a large specimen is close to a hundred pounds, but the head is slenderly-elongate and the mouth less than an inch in circular opening. A whip-like tongue can be continuously darted to the length of a foot. This creature has very powerful front claws, which by retractile action can gouge and tear into the tough composition of termite nests. The tamandua and the silky anteater are smaller, but similarly armed, also with tubular snout and darting tongue. They have prehensile tails, like monkeys, and tear into the tree nests of termites. In the Old World are the ant-eating pangolins of Malaysia and

Africa, in Australia a marsupial anteater and the echidna, with allied species in New Guinea. Thus these wholly unrelated mammals are unique forms of parallelism evolved to subsist upon termites and ants. The echidnas hint of an early try-out along these lines, being remnants of the most primitive of mammals, constructing a nest and laying eggs, but rearing the young with milk. The African aardvark is the most spectacular of anteaters. It lives in southern parts of the continent where the mounds of termites rise like miniature mountain systems—and the aardvark needs such abundance of its chosen food. This heavy, pig-like animal, with tubular snout and excessively long tongue weighs in excess of a hundred pounds. That its powerful, lumbering body is nourished entirely by tiny insects lapped up by darting tongue seems incongruous.

A fair number of birds with strong, hammering beaks are among predatory enemies of termites. The response to partial destruction of nests, however, is swarming activity of remaining workers with grains of repair material.

As tolerated guests within termite structures, are insects which are to be found nowhere else. Small, half-blind burrowing snakes live in the foundations of the structures and some species of lizards lay their eggs within air-conditioned interiors, ideal for hatching purposes, owing to constant temperature and humidity.

My dissertation about termites has possibly gone a bit beyond bounds as compared to that about other forms of insect life. Being a frequent wanderer in warm latitudes I have long been impressed by their activities and importance, plus their rise from cockroach ancestry.

Compared to termites, the true ants, in the average, have even more complicated social habits. To use popular terms, ants are more up-to-date in structure than termites, the latter remaining old-fashioned or primitive in outline with the exceptions of modification of masticating jaws and head equipment of the fighters. They retain abdominal and thoracic outlines of their orthopterous ancestors; also the wings of their temporarily flying members show relationship to cockroaches. Ants, to the contrary, have been designated as "thin-waisted." Their abdominal section joins the thorax in the slender constriction of hornets, also approaches the extremely slender waistline of wasps, there being relationship to both. Such insects form the *Hymenoptera.* Referring back to termites fo comparison, the life history of ants is more complicated. Termites emerge from eggs as nymphs, which are not dissimilar to the parent form. They are able to move about and partake of food without actual nursing. With the true ants the young hatch as helpless grubs, requiring the most painstaking care. From grubs they transform to the pupa stage, soft-bodied and immobile. These delicate, mummy-like pupae require orderly disposal as they pass through this intermediate stage, from which ultimately they will slit the skin and writhe out as perfect ants, although for a time soft and weak, unfit to assist in the work of the colony.

With some of the larger communities of ants, when the colony is bogged down by overwork, waves of fighting members sally forth ahead of a force of carriers on slave-gathering expeditions. Species with weaker fighting forces are raided, their helpless pupae carried home. When these transform as ants they become slaves of the victorious colony. There are different phases of slave raids. The queen of an Asiatic ant lays eggs only to produce waves of fighting raiders and winged females and males to fly forth and establish new colonies. Her warlike raiders are constantly on the go to provide selected slaves that do all the work of the colony.

The architecture of ants' nests, even in the tropics, is not so prominently imposing as the work of termites. While there are arboreal nests and large mounds built on the ground, the nest of many ants are underground. With tougher body covering and endurance to variable temperature and moisture ants surpass the termites by freely reconnoitering in the open. Thus far more hardy, their races greatly exceed the distribution of the soft-bodied "white ants" or termites in extension through the temperate zones.

During tropical adventuring I have seen dramatic demonstrations of the bravery of ants in defending their homes, and their savagery in resenting intrusion where they are foraging. In warm countries many are what the natives call "double-enders"—they both sting and bite. Jaws reek with formic acid and bites are formidable enough. The stings of the larger kinds are excessively painful and may even be dangerous to man. With the exception of ant-eating mammals, with thick or waxy hair to resist ant attack, even the larger animals evade spots where ants are numerous.

My most lively encounter with such insects was with a wave of army ants. It was the first time I had seen them in an advance, during which they are said to resistlessly sweep on. My Honduran guide warned me not to get in their way, but to change our course. I was rash enough to stamp over toward them and see if I could make a break in the wave.

The wave didn't break. As if by magic ants swarmed all over me and their bites burned like sparks. A pool of filthy water saved me further agony. The guide pushed me into it and I conceded that I had learned a bitter lesson. The thought of an experience like that teaches one to be instinctively careful. Yet the alertness of tropical ants may get one into trouble at unexpected times.

Looking up into a small tree, in Brazil, at a handsome snake coiled in perfect symmetry and figuring on how I was going to get him, I rested my hand on the lichen-encrusted trunk in steadying my investigation. Suddenly there was a feeling as if darts were being deeply shot into my arm. The tree was guarded by stinging fire ants and the capture of the reptile was hence carefully done with a noose on a pole. Evidently the reptile was a tolerated visitor in the ants' arboreal domain.

Another tropical experience was a bit more sinister, if the advice of my guide was to be taken literally, and he had a good reputation for jungle knowledge and veracity. It was at a time of day when the sun was setting and tropic darkness not far away. We had stopped to rest; the forest was very still.

Hearing a creeping in the debris close by I saw a large ant and remarked about its size. My companion regarded it very soberly.

"A bad spot to camp," was his remark. "That big ant goes for others. They won't let you stay here. One sting from him and you never forget it."

I watched the big ant, nearly an inch long. It faced us; seemed to be insolently figuring what we would do. Later, on returning to the States I looked up the status of its kind. It belonged to the genus *Paraponera.* Its sting was said to be dangerous and a larger species inhabiting the Amazon basin was alleged to be capable of killing a human of weak physique.

What a difference though, in watching the long, laboring processions of "parasol" ants, a stream of workers returning, each with a piece of green leaf grasped in its jaws and held over its head. Outward bound was another stream headed for some bush or tree to obtain leaf fragments for a fermenting bed they were building underground as food for the colony. That food-bed could be visualized. I had maintained colonies in the laboratory, providing them with rose bushes, of which they are fond. In the underground chamber they packed the leaf fragments in a circular mass as round and symmetrical as a baker's cake. In Panama I have seen these parades of leaf cutters extend for hundreds of feet from the nest to the selected food bush or tree. I have sat and eaten my lunch (a can of tomatoes spread on biscuits) with knees arched over the working parade. The human colossus disturbed them not at all. Regularly spaced along the plodding ranks were the strong-jawed soldiers. Their watch was for small enemies.

All of this goes on, more so in miniature, less ostentatious to the human eye, among the ants of temperate climes. Slave gathering is carried on; battles are fought. In some instances two species may fraternally be tenants of an extensive cellular apartment. Slave gatherers may forage yet repeatedly pass a colony of a different species which they sidestep owing to its nature of spirited attack—and the separation of such colonies may not be more than a few yards.

The sustenance within ant colonies has been classified as indicating the evolution or ascendence of ants. There are the agriculturists as shown by the leaf cutters, which plant their gatherings to produce fermenting or edible fungus beds. Not remote in habits, although engaging in no "farming," are the seed gatherers or harvesting ants which husk and store seeds in granaries. With such kinds the strong-jawed soldiers have plenty to do as seed-crushers, thus opening up the softer parts for the weaker members of their colony.

Other ants subsist largely upon the sugary exudates of aphides or plant lice. Large numbers of these small, soft-bodied insects are maintained in the homes of ants, fed and tended like dairy cattle. Other batches of aphides, on particularly succulent stems, where they are waxing fat, are herded and kept from wandering by barricades built around the stems. Such pastoral habits have brought high specialization among several ants of warmer climes —these known as honey-ants. Concentrating on the storage of sugary fluids and urged by lack of dependence in aphis culture in their particular regions, these ants collect large quantities of the sweet exudates at favorable times. As it is beyond their ingenuity to make casks for storage of such fluids, a cast of workers is adapted to the purpose. These members are fed prodigiously, until their bodies are as round as marbles and they are helpless to get about. The animated casks of nourishment exude honey-dew in liberal quantities under certain strokes of the workers' antennæ.

The kinds of social insects, living in large numbers and with definite castes, includes wasps, hornets and bees. Homes are built of mud, papery pulp and wax. With the permanently winged *Hymenoptera,* nests are mostly constructed of symmetrical cells, the young being individually stowed. Feeding habits are varied. Some young are reared on the bodies of other insects of soft-bodied kinds; others are fed nectar from the flowers. A sweeping, orderly influence controls all of these social kinds, but their nest habits are not so complex as with ants. Of the approximate ten thousand species of wasps and hornets about eight hundred are of social habits. The others, however, build snug nurseries; the young are not cast off to shift for themselves after emerging from the egg, as with the greater number of insects. Among bees, with almost an equal number known as with wasps and hornets, about five hundred kinds are listed as living in large colonies, although the solitary members are solicitous in providing for their larval forms.

With all these phases of seeming superiority among social insects their world-wide abundance is understandable, but despite bulwarks of defense, their systematic habits and shelters, there is a background of hazards, as with all forms of life. The larger insectivorous enemies attack them while foraging or in flight, minute enemies carrying spores of disease invade their structures, while they are powerless to resist some types of parasitic invasion.

A few months ago a group of men gathered on the canvas-covered after-hatch of a small steamer in a tropical port. There was the port manager of the fruit company, the technician who diagnosed troubles of growing bananas and citrous fruits, a professor from the North who annually cruised on small vessels as a vacation, the ship's doctor, and myself. The hatch cover was wet, but we were sprawled on it to cool off. It had been insufferably hot, followed by a downpour. The edge of a cloud, like tar smoke, was still over the sun. The only standing member was the professor, whose white trousers were very properly starched. He inquired of the manager if there was much animal life close to that coastal area.

His query swung my glance toward the shore. There was a sandy beach with fringe of palms that reared in twists and curves. Behind was a patch of low greenery and farther back the paler green of banana planting which appeared to stretch for miles. As a background were lofty hills, dark green with high and heavy verdure.

The manager said that animal life prowled to the very backyard of the fruit company's domain. That someone hearing a wastecan upset a few nights past had looked out and seen a jaguar pawing through the contents; that for years they had had trouble on their nine-hole golf course because tapirs walked across the green and made big dents. The professor thence declared that these thick tropics would long afford a retreat for wild life, and this was encouraging in the face of what spreading cultivation was doing in exterminating animal life in many parts of the world. We discussed this and talked about animal sanctuaries and national parks. The professor heatedly criticized the treatment of the latter; the setting aside of wild, virgin tracts, then cutting them into islands by building too many motor roads.

"It's tough to build a road down here," said the manager. "We have to steam-spray the bed of our banana railway to stop the encroachment of vines. We cut a surveying trail back toward the hills last year. We tried to look it up not long ago and there wasn't a sign of it. That's how the jungle comes back."

"Whole parts of this country could be taken over if it wasn't for the bugs," declared the ship's doctor. "Mosquito control is ultimately going to do it."

We argued about what had been done along these lines. How the yellow-fever mosquito had been conquered; that in the past maps showing incidence of yellow fever had deplorably large, shaded portions; now the maps had but isolated spots, here and there.

The doctor was stubborn. He referred to widespread, tropical malaria.

"Take the native settlements in this country," he insisted. "At least sixty per cent of the population have malaria. These natives are sick, but most of them hardly know it. They have a partial resistance to it, but pass it on to persons who haven't gone through generations under such conditions, and these are liable to get bumped off."

Here was a line of talk I had often heard in hot countries—man's discussion of conquering the tropics. Swinging into the doctor's theme I listed some other tropical "bugs," equally as formidable as mosquitoes. There was *Triatoma,* for instance, a genus of blood-sucking hemipterons suspected of transmitting the organisms of Chagas fever. I remembered a jar crawling with these sinister insects at the Gorgas Memorial Laboratory in Panama. Dr. Herbert Clark, steadily battling with tropical problems, had them under close study. He had told me that as yet no successful treatment had been discovered for Chagas fever. The trypanosomes in the blood did not appear to be eliminated even after intra-venous injections of arsenical solutions, which wiped out other forms of pathogenic protozoa.

The ship's doctor nodded at my reiteration of disease-transmitting insect control, but took another blast at mosquitoes.

The chief radio operator had joined us and asked if he could put in a word. He said the problem might be solved by radio waves, as hinted by a talk he had heard delivered at an electrical convention. One of the large corporations, he said, was working on a powerful transmitter designed to kill every small soft-bodied flying insect, actually in flight, for a distance of several miles. This transmitter would be operated by clock mechanism and radiate its lethal waves at intervals, throughout the night, when disease-transmitting forms were on the wing.

There was instant reaction from the fruit company's technician, who was an economic entomologist, but had been lying, seemingly dozing, as we talked. He sat up straight and glared at the elucidator of alleged radio marvels.

"They'll never bring that thing down here," he shouted. "Do you know what they're trying to do—they're monkeying with the buzz saw!"

We swung to get the reason for this outburst.

"How about the parasites," he angrily continued. "They'd kill all sorts of useful things along with the bad. Those plantings ashore would go to the dogs without parasitic control."

As I was already at work on this book the incident seemed fitting to place among the notes of the manuscript.

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